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Personality Traits of Athletes as Measured by the MMPI[1]

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Grinnell College,
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Abstract

In this study, the Minnesota Multiphasic Personality Inventory (MMPI) was used to compare the personality ratings of the following groups of college students: 1. Freshman and upper-class athletes and non-athletes; 2. Freshman and varsity athletes who participated in only team, individual, or team and individual sports; and 3. Athletes who were rated as poor or good competitors.

On the interest (Mf) variable, the non-athletes scored significantly higher than the athletes. Freshman athletes, freshman non-athletes, and upper-class non-athletes scored significantly higher than the varsity athletes on the anxiety (A) variable. Varsity athletes and the upper-class non-athletes scored significantly higher than the freshman athletes and non-athletes on the dominance (Do) variable. On the social responsibility (Re) variable, the upper-class non-athletes scored significantly higher than the freshman athletes and non-athletes and the varsity athletes.

Varsity athletes who participated in only individual sports scored significantly higher on the depression (D) variable than those who participated only in team sports. On the psychasthenia (Pt) variable, the participants in varsity individual sports scored significantly higher than the athletes who participated in both team and individual varsity sports.

Twenty-two items that discriminated significantly between poor and good competitors were selected from the 550 items of the MMPI.

DESIRABLE changes in personality and improvement in social adjustment and in human relations have been listed as outcomes of physical-education and athletics programs (4). On the other hand, critics have charged that physical-education and athletics programs often have adverse effects upon the attainment of such outcomes (1, 16).

Although much controversy concerning the effects of participation in programs of physical education and athletics upon the personalities of the participants has arisen, relatively few attempts to measure these effects objectively have been made. Most of the studies which have been completed may be arbitrarily classified into one of the following categories:

1. Studies chiefly concerned with the effects of programs of physical education and athletics on the personal and social adjustment of the participants (2, 3, 5, 17, 21).

2. Studies chiefly concerned with the effects of physical education and athletics programs on the emotional behavior of the participants (11, 12, 13, 22).

[1]This study was made in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Division of Physical Education in the Graduate College of the State University of Iowa, 1957, under the direction of Dr. Louis E. Alley, Division of Physical Education and Dr. Leonard D. Goodstein, Department of Psychology.

3. Studies chiefly concerned with the relationships between physical ability, physical fitness, physical development, types of physical activity, and personality traits (6, 9, 14, 17, 20, 23, 24, 26, 28, 30).

The primary purpose of this study was to compare, through the use of the Minnesota Multiphasic Personality Inventory (MMPI), the personality ratings of the following groups of college students:

1. Freshman athletes and freshman non-athletes.
2. Varsity athletes and upper-class non-athletes.
3. Varsity athletes and freshman athletes.
4. Athletes who participated only in team sports and athletes who participated only in individual sports.
5. Athletes who participated only in team sports and athletes who participated in both team and individual sports.
6. Athletes who participated only in individual sports and athletes who participated in both team and individual sports.
7. Athletes who were judged to be poor competitors and athletes who were judged to be good competitors.

A secondary purpose of this study was to select, from the MMPI, test items that would discriminate between poor competitors and good competitors.

Procedure

The subjects for this study were male students who were enrolled in Grinnell College[2] during the academic year of 1955-56.

CLASSIFICATION OF SUBJECTS

Athletes. The athletes were those members of the football, basketball, wrestling, swimming, track, cross-country, tennis, and golf squads who consistently attended practice throughout the respective seasons. Sixty-three students were classified as freshman athletes. The varsity athletes were 78 upper-class sudents, of whom 28 were sophomores; 26, juniors; and 24, seniors.

Non-athletes. The freshman non-athletes were 71 freshman students who had not earned a major award in high school competition and who did not participate in college athletics during the year in which the study was conducted. The upper-class non-athletes were 74 upper-class students who had not earned a major award in high school competition and who had not been members of a sports squad while in college. The group of upper-class non-athletes was composed of 37 sophomores, 20 juniors, and 17 seniors.

Sports groups. The groups of freshman and varsity athletes were each subdivided into three groups according to the types of sports in which the athletes participated. Those who participated only in football and basketball were placed in the team sports groups. Those who particiated in cross country, swimming, wrestling, track, golf, or tennis were placed in the individual sports

[2]The writer wishes to express his appreciation to the administrative officers and to the students of Grinnell College for their interest and co-operation in this study.

groups. Those who participated in both team sports and individual sports were placed in the team-individual sports groups.

Competitors. To select the poor and good competitors, each athlete was rated on two traits—competitive spirit and competitive performance. Competitive spirit was defined as the determination of the athlete to win in a competitive situation. Competitive performance was defined as the ratio between the actual performance of the athlete in a competitive situation and the performance which might reasonably be expected of the athlete. Within each sports squad, the freshman and varsity athletes were, on the two traits, rated by the squad members and the coach. A five-point absolute scale and a rank-order listing were used for the rating on each trait; thus, for each athlete there were four final ratings. The mean of the ratings by the squad members and the rating by the coach was used as the final rating for each squad member. Those athletes within each sports group who appeared in the upper quartiles on three of the four final ratings were selected as good competitors. Those athletes who appeared in the lower quartiles on three of the four final ratings were selected as poor competitors.

Two estimates of the reliability of the ratings were obtained. Ratings for the members of the varsity basketball squad were obtained at mid-season and at the end of the season. The Pearson product-moment coefficients of correlation for the two ratings appear in Table 1. The absolute ratings for the members of the indoor track squad were compared with the absolute ratings of the same athletes who were members of the outdoor track squad. The coefficients for the two absolute ratings are shown in Table 2.

TABLE 1

Reliability Coefficients between Mid-Season and End-of-Season Competitive Ratings for Varsity Basketball Players (N = 13)

Rating	Reliability Coefficient[1]
Rank-order performance	.96
Rank-order spirit	.91
Absolute performance	.73
Absolute spirit	.90

[1]An r of .553 is required for significance at the 5 per cent level of confidence for a sample in which N = 13.

TABLE 2

Reliability Coefficients Between Competitive Ratings for Members of the Indoor Track Squad and Ratings for the Same Athletes as Members of the Outdoor Track Squad (N = 15)

Rating	Reliability Coefficient[1]
Absolute-performance	.73
Absolute-spirit	.74

[1]An r of .514 is required for significance at the 5 per cent level of confidence for a sample in which N = 15.

Analysis of Data

The raw scores on the MMPI variables were corrected for K, a suppressor variable score, and converted to T scores in accordance with directions presented in the manual for the use of the MMPI (10). Raw scores for the manifest anxiety (A) (25), dominance (Do) (7), and social responsibility (Re) (8) variables were used in the analysis. In accordance with the accepted usage of the validity scales of L and F the subjects who had raw scores of 7 or above on the L scale and 17 or above on the F scale were eliminated from the study. Sixteen subjects were dropped because of high L scores, and no subjects were dropped because of high F scores.

An analysis of variance of means (29) was used to determine whether significant differences for any of the MMPI variables existed 1. between the groups of freshman athletes, freshman non-athletes, varsity athletes, and upper-class non-athletes; 2. between the groups of freshman and varsity athletes who participated in individual sports, team sports, or team-individual sports; and 3. between the freshman and varsity poor and good competitors. In each instance in which a significant F was obtained, the t test was used to determine which differences were significant. Differences that met the requirements for a P of .05 were considered significant. In all computations, four decimal places were retained until the final figures were rounded to two decimal places for use in the tables.

COMPARISON OF ATHLETES AND NON-ATHLETES

In the comparisons of the athletes and non-athletes significant F's were obtained for the variables of interest (Mf), anxiety (A), dominance (Do), and social responsibility (Re). Table 3 shows the results of the t test for the interest (Mf) variable. The means of the scores of the interest (Mf) variable were significantly higher for the non-athletes than for the athletes. The results of the t test for the anxiety (A) variable are shown in Table 4. The means of the scores of the freshman athletes, upper-class non-athletes, and freshman non-athletes were significantly higher than the means of the scores of the varsity athletes.

In the comparison of the means of the scores on the dominance (Do) variable, the means for the upper-class students (athletes and non-athletes) were significantly higher than the means for the freshmen (athletes and non-athletes). Table 5 presents the results of the t test for the dominance (Do) variable. Table 6 shows the results of the comparisons for the social responsibility (Re) scale. Upper-class non-athletes scored significantly higher on this scale than freshman athletes and non-athletes and varsity athletes.

COMPARISONS OF SPORTS GROUPS

The analysis of variance of the means of the groups of freshman competitors in team sports, individual sports, and team-individual sports revealed that for the variables studied no significant differences existed between the groups. For the varsity athletes in team sports, individual sports, and team-individual sports, the means of the scores on the depression (D) and psychasthenia (Pt)

TABLE 3

t Test of Differences Between Means of MMPI Interest (Mf) T Scores for Freshman Non-Athletes, Freshman Athletes, Upper-Class Non-Athletes, and Varsity Athletes

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Freshman non-athletes	62.61	9.29	4.80	1.98	2.43*
Freshman athletes	57.81	10.04			
Freshman non-athletes	62.61	9.29	2.65	1.63	1.63
Freshman athletes	65.26	10.34			
Freshman non-athletes	62.61	9.29	3.85	1.61	2.39*
Varsity athletes	58.76	9.34			
Freshman athletes	57.81	10.04	7.45	1.68	4.43*
Upper-class non-athletes	65.26	10.34			
Freshman athletes	57.81	10.04	.95	1.66	.57
Varsity athletes	58.76	9.34			
Upper-class non-athletes	65.26	10.34	6.50	1.59	4.08*
Varsity athletes	58.76	9.34			

[1] t for P of .05 = 1.969; df = 282.
*Significant at or beyond 5 per cent level of confidence.

variables were found to differ significantly. Table 7 shows the results of the t test of the differences between the means of the scores of the varsity athletes on the depression (D) variable. The varsity athletes who participated in individual sports scored significantly higher than those who participated in team sports and in team-individual sports. The results of the t test of the differences between means of the scores on the psychasthenia (Pt) variable for the groups of varsity athletes are presented in Table 8. The varsity participants in individual sports scored significantly higher on the psychasthenia (Pt) variable than the varsity participants in team-individual sports.

COMPARISONS OF COMPETITORS

The means of the scores on all the MMPI variables except the dominance (Do) variable were, by an analysis of variance, found not to differ significantly for the poor and good freshman and varsity competitors. The t test of the differences between the means revealed that both poor and good varsity competitors were more dominant than the freshman competitors. This finding was in agreement with the comparisons of freshman and varsity athletes and non-athletes, which comparisons indicated that the upper-class students scored

TABLE 4

t Test of Differences Between Means of MMPI Anxiety (A) Raw Scores for Freshman Non-Athletes, Freshman Athletes, Upper-Class Non-Athletes, and Varsity Athletes

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Freshman non-athletes	12.96	7.55	1.58	1.16	1.36
Freshman athletes	11.38	6.55			
Freshman non-athletes	12.96	7.55	2.03	1.11	1.82
Upper-class non-athletes	10.93	6.49			
Freshman non-athletes	12.96	7.55	4.19	1.10	3.81*
Varsity athletes	8.77	6.48			
Freshman athletes	11.38	6.55	.45	1.15	.39
Upper-class non-athletes	10.93	6.49			
Freshman athletes	11.38	6.55	2.61	1.13	2.30*
Varsity athletes	8.77	6.48			
Upper-class non-athletes	10.93	6.49	2.16	1.09	1.99*
Varsity athletes	8.77	6.48			

[1]t for P of .05 = 1.969; df = 282.
*Significant at 5 per cent level of confidence.

significantly higher on the dominance (Do) variable than the freshman students.

SELECTION OF ITEMS INDICATING COMPETITIVE BEHAVIOR

In an attempt to select, from the 550 MMPI True-false items, items that would discriminate between poor and good competitors, the responses of the poor and good varsity competitors were subjected to an item analysis. The "true" response for each item was arbitrarily established as the correct answer. For each item, the proportion of the poor and good competitors who selected "true" as a response was determined. The critical ratio of the proportions was determined for each item. The critical ratios for the 22 items that discriminated significantly between the two groups are presented in Table 9. The numbers of the items as they appear in the total MMPI scale and the number of true responses given to each item by the members of each group are also listed in the table.

In order to estimate the validity of the 22-item scale as a measure of competitive behavior, the scores that the 78 varsity athletes made on the 22 items were correlated with the absolute ratings of competitive spirit. The coefficient of correlation between the scores on the 22 items and the absolute ratings of

TABLE 5

t Test of Differences Between Means of MMPI Dominance (Do) Raw Scores for Freshman Non-Athletes, Freshman Athletes, Upper-Class Non-Athletes, and Varsity Athletes

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Freshman non-athletes	10.59	2.49			
			.12	.40	.30
Freshman athletes	10.71	2.54			
Freshman non-athletes	10.59	2.49			
			1.25	.41	3.15*
Upper-class non-athletes	11.84	2.03			
Freshman non-athletes	10.59	2.49			
			1.50	.39	3.84*
Varsity athletes	12.09	2.39			
Freshman athletes	10.71	2.54			
			1.13	.41	2.76*
Upper-class non-athletes	11.84	2.03			
Freshman athletes	10.71	2.54			
			1.38	.40	3.41*
Varsity athletes	12.09	2.39			
Upper-class non-athletes	11.84	2.03			
			.25	.39	.65
Varsity athletes	12.09	2.39			

[1]t for P of .05 = 1.969; df = 282.
*Significant at 5 per cent level of confidence.

competitive performance was −.67, and the coefficient of correlation between the 22 items and the absolute ratings of competitive spirit was −.65. These coefficients were negative since a high score on the 22 items and a low score on the rating scale indicate good competitive behavior.

In a comparison of the physical ability of the poor and good varsity competitors the motor quotients (18) for the members of the two groups were compared. The mean and the standard deviation of the motor quotients were, for the good competitors, 100.88 and 9.54, respectively, and for the poor competitors, 98.31 and 5.36, respectively. The difference between the means was 2.57 and the t ratio was 1.17 which was not found to be significant.

To establish further the validity of the 22 items as a measure of competitive behavior, the 22 items, the 15 items of the L scale, and three other MMPI items chosen at random were combined in a 40-item test and administered to 21 athletes of the State University of Iowa varsity track squad. The coach of the team was asked to rank the members of the squad according to his

TABLE 6

t Test of Differences Between Means of MMPI Social Responsibility (Re) Raw Scores for Freshman Non-Athletes, Freshman Athletes, Upper-Class Non-Athletes, and Varsity Athletes

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Freshman non-athletes	16.97	2.93	.26	.56	.46
Freshman athletes	16.71	3.10			
Freshman non-athletes	16.97	2.93	1.25	.54	2.31*
Upper-class non-athletes	18.22	2.90			
Freshman non-athletes	16.97	2.93	.09	.53	.17
Varsity athletes	17.06	3.80			
Freshman athletes	16.71	3.10	1.51	.56	2.70*
Upper-class non-athletes	18.22	2.90			
Freshman athletes	16.71	3.10	.35	.55	.64
Varsity athletes	17.06	3.80			
Upper-class non-athletes	18.22	2.90	1.16	.53	2.19*
Varsity athletes	17.06	3.80			

[1]t for P of .05 = 1.969; df = 282.
*Significant at 5 per cent level of confidence.

TABLE 7

t Test of Differences Between Means of MMPI Depression (D) T Scores for Varsity Athletes in Team Sports, in Individual Sports, and Team-Individual Sports

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Team-individual sports	49.35	7.81	2.45	2.70	.91
Team sports	46.90	8.66			
Team-individual sports	49.35	7.81	5.36	2.38	2.66*
Individual sports	54.71	9.20			
Team sports	46.90	8.66	7.81	2.48	3.15*
Individual sports	54.71	9.20			

[1]t for P of .05 = 1.992; df = 75.
*Significant at 5 per cent level of confidence.

TABLE 8

t Test of Difference Between Means of MMPI Psychasthenia (Pt) T Scores for Varsity Athletes in Team Sports, in Individual Sports, and in Team-Individual Sports

Groups	M	S.D.	Diff.	S.E. of Diff.	t[1]
Team-individual sports	53.00	8.92	4.95	2.75	1.80
Team sports	57.95	8.27			
Team-individual sports	53.00	8.92	7.06	2.42	2.92*
Individual sports	60.06	2.89			
Team sports	57.95	8.27	2.11	2.52	.84
Individual sports	60.06	2.89			

[1]t for P of .05 = 1.992; df = 75.
*Significant at 5 per cent level of confidence.

TABLE 9

Critical Ratios for MMPI Items Which Discriminated Between Poor and Good Varsity Competitors

MMPI Item	Number of "True" Responses		Critical Ratio[1]
	Good Competitors (N = 26)	Poor Competitors (N = 26)	
3	20	13	2.01
8*	18	24	2.13
18	26	22	2.05
127*	6	15	2.55
129	13	5	2.35
163	24	18	2.13
198	17	9	2.22
199*	21	26	2.31
261	10	3	2.25
302	26	21	2.31
328*	3	10	2.25
346*	2	9	2.39
348	13	6	2.01
376	26	22	2.05
399	20	13	2.01
470*	0	4	2.05
480*	0	5	2.31
484	8	2	2.13
508	26	22	2.05
531*	0	7	2.89
533*	20	25	2.07
556*	7	18	3.06

[1]t for P of .05 = 2.008; df = 50.
*Item for which the answer for a good-competitor rating should be "false."

estimate of their competitive behavior. The 22 items were scored and the results correlated with the rank-order listing made by the coach. The rank-difference coefficient of correlation obtained was .63 which is significant at the 5 per cent level of confidence.

Summary and Conclusions

1. On the interest (Mf) variable, the non-athletes scored significantly higher than the athletes.
2. On the anxiety (A) variable, the varsity athletes scored significantly lower than the freshman athletes, freshman non-athletes, and upper-class non-athletes.
3. On the dominance (Do) variable, the varsity athletes and the upper-class non-athletes scored significantly higher than the freshman athletes and non-athletes.
4. On the social responsibility (Re) variable, the upper-class non-athletes scored significantly higher than the freshman athletes and non-athletes and the varsity athletes.
5. No significant differences were found between the means of the scores on any of the MMPI variables for the freshman participants in individual sports, in team sports, and in team-individual sports.
6. On the depression (D) variable, the varsity athletes who participated in individual sports but not in team sports scored significantly higher than the athletes who participated in only team sports. On the same variable, the varsity athletes who participated in only individual sports scored significantly higher than the varsity athletes who participated in team-individual sports.
7. On the psychasthenia (Pt) variable, the participants in varsity individual sports scored significantly higher than the participants in varsity team-individual sports.
8. On the dominance (Do) variable, both the poor and good varsity competitors scored significantly higher than freshman poor competitors.
9. By means of an analysis of the 550 items of the MMPI, 22 items which discriminated significantly between the poor and good competitors were obtained.

In conclusion, this study has determined that differences in personality as measured by the MMPI do exist between athletes and non-athletes and between participants in individual sports, in team sports, and in team-individual sports. Evidence has been presented which indicates that some items of the MMPI discriminate between athletes rated as poor and good competitors. Collectively, these results indicate that the MMPI has demonstrated merit as an instrument of measurement of personality traits of participants in programs of physical education and athletics.

Many opportunities for further study exist through the use of the MMPI in the determination of cause and effect relationships between participation in various programs of physical education and athletics and changes in the personalities of the participants. In order to validate the items which dis-

criminated between poor and good competitors in this study, another item analysis of the answers of poor and good competitors on the MMPI is needed.

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Reliability of Certain Skill Tests for Junior High School Girls

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Abstract

The reliability of two motor ability and eight sport skill tests for junior high school girls was studied. The Scott and a revised Humiston were the motor ability tests used. Most of the eight sport skill tests were revised or devised by the author. Results showed the following to be reliable: Revised Humiston, best of 2 trials; Scott, average T-score; volleyball volley, 3 trials; volleyball serve, 20 trials; basketball ball handling and wall pass, 3 trials; basketball shooting, 4 trials; softball overhand distance throw, 1 trial; batting, 5 trials; underhand accuracy throw, 30-40 trials.

FOR SOME TIME the author has been interested in determining the effectiveness of a basic skills curriculum with junior high school girls. In order to equate groups for such a study, some method of judging general motor ability at the beginning of the study was necessary. To determine the degree of ability in various sport skills following instruction, reliable skill tests in various sports which were included in the curriculum of the junior high school studied, were needed. A survey of the literature revealed little or no evidence of the reliability of motor ability and sport skill tests for junior high school girls. Therefore, it was necessary to study certain tests before a curricular experiment was possible.

Purpose

The purpose of this study was to determine the reliability of certain motor ability tests and skill tests in volleyball, basketball, and softball when used with junior high school girls.

Procedure

Motor Ability Tests. Two motor ability tests which have been established for college women, the Scott test and the Humiston test, were used. The Humiston test was revised so that the size of the course would fit the junior high school gymnasium (41 ft. x 72 ft.). In making this adjustment the percentage of the distance of the total test course which was involved in the dodging run was kept constant. The height of the box was lowered from three and one-half feet to three feet, and the number of trials was increased. Two trials of the test were administered on one day and two more a few days later.

Scores were obtained on these two tests for all seventh- and eighth-grade girls enrolled in Morgan Junior High School, Seattle, during the fall term, 1955, and for all seventh-grade girls enrolled during the fall, 1956. Two trials of the Humiston test were administered and the test was repeated during the following class period. The best of the first two trials was correlated with the

best of the second two. The number of trials suggested by Scott for each of the tests in the battery which used the dash, wall pass, basketball distance throw, and broad jump, were used. The complete test was repeated. The best of the three trials for the first administration was correlated with the best of three trials on the second for each of these tests. To determine whether the sum of three trials would be more reliable than the best, the sum of the first three trials of the dash were correlated with the sum of the three trials of the second administration of this test.

The mean and standard deviation for each item of the Scott battery were calculated and T-scales were constructed. The T-scores were averaged to give the score for the total test. The total score for the first administration was then correlated with the total for the second administration to determine the reliability of the battery.

The scores on the Humiston and Scott tests were intercorrelated to determine whether the two tests were measuring the same type of ability.

The scores on each test were correlated with the average T-score on eight skill tests which were administered following instruction in volleyball, basketball, and softball.

Sport Skill Tests. During the year 1955-56, skill tests were set up in volleyball, basketball, and softball, since these were the activities to which the greater percentage of the physical education instruction during the year was devoted. No attempt was made to make this a battery of tests which would evaluate all abilities involved. The purpose was simply to test a sample group of skills which could indicate the ability of the students to apply the knowledge and skill gained in a basic skills course to specific sport skills involving throwing, striking, and running. The tests had to be such that they could be administered in the time allotted the investigator by the junior high school instructor. Every attempt was made to avoid interference with the normal progression of the school. Unfortunately, time did not allow for the administration of the running test which was to have been included and therefore, the ability to move the body about rapidly is sampled only in the ball-handling and shooting tests. A total of eight tests were administered to all seventh- and eighth-grade girls.

Two tests were used at the end of instruction in volleyball. One was the well-known 30-second repeated volleys test using a three-foot restraining line. Three trials were given. The serve test involved the ability to control force, the highest score being given for the area within three feet of the baseline. The degree of accuracy involved was slight since the only requirement was that the ball land between the sidelines.[1]

Three tests were used at the end of the basketball unit. One was a revised version of the Edgren Ball Handling Test in which the target on the wall was reduced from three feet to two feet, the distance between the right and left

[1]Detailed description of the tests can be secured by contacting the author.

restraining lines from six feet to five feet six inches and the distance of the restraining line from the wall from eight feet to seven feet six inches. The score was the number of good hits in 30 seconds. The wall pass test included a target of three concentric circles on the wall, and an eight foot restraining line. It was scored in two ways: The score according to where the ball hit on the target and the score simply as the number of hits made against the wall. The shooting test used the usual 30-second test with two changes. To avoid the possibility that a student might take up her position beside the basket and recover the ball and lift it into the basket without moving, a seven-foot semi-circular restraining line behind which all shots were taken was drawn around the basket. Because it was felt that a hit on the rim, which actually indicated a more accurate shot than one missing entirely, often caused a handicapping loss of time in ball recovery, extra balls were available behind the restraining line and could be substituted when a rim ball bounced far from the basket.

In softball three tests were administered: overhand distance throw, underhand accuracy throw, and batting. The field was marked at five-foot intervals and three trials were given for the distance throw. A circular target 48 inches in diameter containing three concentric circles and a 30-foot restraining line were used in the accuracy test. The students threw underhand from a line 30 feet from the target. Two trials of ten throws each were given. To evaluate batting, a batting tee was used. The test involved the distance that the ball could be batted and five trials were given.

The reliability of various scoring methods was determined by correlating scores made on repetitions of the test or by correlating the totals of the odd and the even scores. When the latter method was used, the reliability of the total test was predicted by use of the Spearman-Brown Prophecy formula. The mean and the standard deviation for each of the eight tests were computed, and T-scales were constructed.

Results

Motor Ability Tests. Two hundred and 34 seventh and eighth graders were tested in the fall of 1955. When the best of the first two trials on the adapted Humiston test was correlated with the best of the second two trials, the coefficient was found to be $.93 \pm .005$. A check on one trial's reliability for this age group gave a coefficient of .77, which is too low to be accepted for a single item test. When these results were checked in the fall of 1956, it was found that the best of two trials gave a reliability coefficient of .91 using 134 seventh-grade girls.

Reliability coefficients for the best of three trials on the four items of the Scott battery are shown in Table 1. Since the reliability of the best of three trials on the dash was found to be only .61, the correlation of the sum of trials 1 and 3 with 2 and 4 was calculated on 100 seventh graders in 1956. The coefficient was found to be .71. The Spearman-Brown Prophecy Formula was applied, and it was found that the coefficient predicted for the sum of four trials was .83 and for the sum of five, .86. To determine the reliability of the

TABLE 1
Reliability of Motor Ability Tests

Test	Grade	N	Trials	r
Scott	7th and 8th	234	best of 3	
Basketball throw				.83
Broad jump				.90
Wall pass				.69
Dash				.61
Total (average T-score)				.85
Humiston	7th and 8th	234	best of 2	.93
			1 with 2	.77
	7th	134	best of 2	.91

total Scott test, the averages of the T-scores for the two administrations were intercorrelated. The coefficient was found to be .85±.012.

When the adapted Humiston test was correlated with the Scott, the coefficient was found to be .60, showing that, while there is a subsantial relationship between them, the two tests do not measure exactly the same ability or abilities. Examination of the two tests would lead one to expect this, since the only running involved in the Scott battery used for this study consisted of a short straight-away dash while the Humiston test includes a dodging run which is approximately 40 per cent of the test in distance, and for the average girl who does not exhibit fear of climbing the ladder, somewhere near 50 per cent of the test time. Also, this battery of the Scott test includes nothing which involves lowering and raising the body weight or climbing, all of which are a part of the Humiston. Because the Scott test gives individual scores for various items, it has the advantage of being to some extent diagnostic. The Humiston test yields one score and only through notes made of observations is there any indication of the particular skills that are poorly performed. On the other hand, because it does give one score, it is a very rapid screening device. Both tests can be reliable with this age group, if sufficient trials are administered.

Sport Skill Tests. The reliability coefficients for the volleyball tests are shown in Table 2. Either the best or the sum of three trials on the volley test gives an acceptable score for this age group. Twenty trials are necessary for a reliable score on this serve test.

The results reported in Table 3 indicate that the sum of three trials gives a reliable score for the basketball ball-handling and wall-pass tests, regardless of whether the score for the latter is figured according to the values of the areas hit or the number of passes made. These two methods of scoring rank students very similarly, as shown by the correlation coefficient of .90. In general, it was found that six trials were necessary in order to obtain a reliability coefficient of over .80 on the shooting test. However, it is possible that under

some circumstances four trials would be sufficient, since the results on a group of 200 seventh and eighth graders showed a predicted coefficient of .82 for four trials. Since six trials of this test had been administered, it was possible

TABLE 2
Reliability of Volleyball Skill Tests

Test	Grade	N	Trials	r	Predicted for 3 Trials
Volley	7th and 8th	199	1st with 2nd	.73	.89
	7th and 8th	199	best with 2nd best of 3	.94	
	7th	136	1st with 2nd	.69	.81
	7th	136	2nd with 3rd	.71	.83
	7th	136	1st with 3rd	.71	.83
					Predicted for 20 Trials
Serve	7th and 8th	196	10 odd with 10 even	.69	.81
	7th	136	10 odd with 10 even	.66	.80

TABLE 3
Reliability of Basketball Skill Tests

Test	Grade	N	Trials	r	Predicted 3 Trials
Ball handling	7th and 8th	228	1st with 2nd	.64	.84
			2nd with 3rd	.67	.86
	7th	136	1st with 2nd	.64	.84
			2nd with 3rd	.66	.85
			1st with 3rd	.62	.82
Wall pass					
Accuracy	7th and 8th	237	1st with 2nd	.58	.81
No. of passes	7th	136	1st with 2nd	.66	.85
			2nd with 3rd	.68	.86
			1st with 3rd	.63	.84
Accuracy with No. of passes	7th and 8th	237	3 Trials	.90	
Shooting	7th and 8th	235	1, 3, 5 with 2, 4, 6	.69	6 Trials .81
			1st with 2nd	.43	3 Trials .69
					6 Trials .81
			1, 3 with 2, 4	.65	4 Trials .79
	7th and 8th	200	1, 3 with 2, 4	.71	4 Trials .82
Jump and reach	7th	50	best of 3 with best of 3	.84	

to check the accuracy of the results obtained through use of the prediction formula. It is interesting to note (Table 3) that the coefficient which resulted from correlating trials one and two and predicting for three was identical with that found by correlating the three trials 1, 3, 5 with 2, 4, 6 (.69). The jump and reach was not used during the first year of the study but, since it is a test used in evaluating basketball skills, the results of a study of its reliability with 50 seventh graders the following year are included in the table. The best of three trials is reliable for this age group.

The softball skill test results appear in Table 4. It was found that the first trial of the distance throw correlated with the second .94. As was expected,

TABLE 4
Reliability of Softball Skill Tests

Test	Grade	N	Trials	r	Predicted
Overhand Throw (Distance)	7th and 8th	239	1st with 2nd	.94	
	7th	141	1st with 2nd	.94	
Underhand Throw (Accuracy)	7th and 8th	232	10 odd with 10 even	.42	20 Trials .59 30 Trials .68
	7th	52	10 odd with 10 even (following instruction)	.55	20 Trials .71 30 Trials .79
Batting (tee)	7th and 8th	235	1, 3 with 2, 4	.61	4 Trials .76 5 Trials .80
			avg. of best 3 with avg. of 5	.97	
	7th	138	1, 3 with 2, 4	.66	4 Trials .80

the underhand throw for accuracy was much less reliable. Twenty trials were administered and the correlation of the odd and even scores resulted in a coefficient of .42. The predicted reliability for 20 trials was found to be .59. When the seventh graders were tested following the basic instruction, the results showed a somewhat higher reliability. With this age group at this skill level, apparently 30 to 40 trials are necessary for a reliable test of this type.

To evaluate batting, a batting tee was used. The test involved the distance that the ball could be batted. When the sum of trials one and three was correlated with that of two and four, a coefficient of .61 was found. The predicted reliability for five trials was found to be .80. The seventh graders'

results indicate that four trials are reliable (.80). Inspection of the scores indicated that frequently one trial was considerably less than the others, and it was reasoned that the best three trials which allowed for discarding the one or two trials which were inconsistent with the others might be a more valid measure of batting ability. When the average of the best three was correlated with the average of all five trials, the correlation coefficient was found to be .97, indicating that both scores ranked the students in approximately the same order.

As was anticipated, it was found that for this age group more trials are necessary on those tests which involve accuracy than has been found to be the case for older groups.

Conclusions

The results indicate that for junior high school girls:

1. The best of two trials for the revised Humiston test gives a reliable score.
2. The best of three trials gives a reliable score for the basketball distance throw and broad jump of the Scott battery.
3. The average of the T-scores for the four tests of the Scott battery gives a reliable score.
4. While there is considerable relationship between the Scott and Humiston tests, they are not entirely measuring the same ability or abilities.
5. A single trial of the overhand distance throw is reliable.
6. Three trials give a reliable score for the volleyball volley, and the basketball ball-handling and wall-pass tests.
7. Four or five trials are necessary for a reliable score on the basketball-shooting and the softball-batting tests.
8. The sum of 20 trials gives a reliable score for the volleyball service test.
9. Thirty to 40 trials are necessary for a reliable score on this underhand accuracy throw test.

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Relationship of Tightness of Pectoral Muscles to Round Shoulders in College Women

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Abstract

The purpose of this study was to determine the degree of relationship between round shoulders and tightness of the pectoral muscles. Tests to evaluate shoulder position and to determine pectoral tightness were administered to 124 college women. There was no correlation found to exist between round shoulders and tightness of the pectoral muscles in college women.

TIGHTNESS of the pectoral muscles has been given as a cause of round shoulders in many discussions of postural defects. Proof of relationship between round shoulders and tightness of the pectoral muscles does not seem to have been established, however. It is the purpose of this study to determine to what degree, if any, correlation exists between these two postural factors.

Review of Literature

Many of the studies concerning the position of the shoulder girdle have to do with flexibility and joint function. The following discussions refer primarily to those having to do with defining normal shoulder girdle position and defective shoulder girdle position, especially "round shoulders."

According to Bowen and Stone (1) in *Applied Anatomy and Kinesiology*, for normal posture of the shoulder girdle, the clavicle should be approximately horizontal and the scapula should lie flat against the chest wall on the back. They later discuss factors which may cause changes from positions they describe as the normal, such as occupations and activity done with the arms in front of the body. These tend to increase the bulk, strength, and tone of the muscles on the front and to modify their development so as to make them permanently shorter, while they have the opposite effect on the back group.

Bowen and Stone in this book also suggest distance between the scapulae as a method of determining defective shoulder girdle position, and state that the scapulae should be four inches apart when a person is standing in a normally erect, relaxed position.

Lee and Wagner (7) in their book, *Fundamentals of Body Mechanics and Conditioning*, state that the usual results of a prolonged habit of relaxing the muscles of the upper back thus allowing the shoulders to droop forward and the chest to be depressed are weakened and stretched upper back muscles, especially the upper erector spinae and rhomboids and foreshortened chest muscles, particularly the pectoralis major and minor.

Hawley (4) in her book, *The Kinesiology of Corrective Exercises,* states that scapular abduction generally causes the vertebral border of the scapula to project more or less prominently on the back. Later, in discussing the pectoralis major, she states that if it is markedly shortened, as is likely to be the case when it is very strong in comparison with the upper back muscles, it constitutes one of the most serious factors producing malposture of the shoulder region.

In his article, "Postural Stress and Strain in Occupational Therapy," Lowman (8) states that faulty relationships between opponent muscles in a deviated segment such as round shoulder, will mean that pectorals will be short and tight as against weakened and overstretched rhomboids.

Cureton (3) in his article, "Flexibility as an Aspect of Physical Fitness," makes a similar statement concerning muscular imbalance.

"It is common practice to give considerable flexibility work in body building and corrective classes. The assumption underlying this is that certain of the muscle groups become unduly shortened by being exercised in short, static positions and with the opposing muscle groups poorly conditioned, the result is an imbalance of the muscular tensions for best posture. One method is to shorten up the weak antagonists, and this is usually done. The other approach is to stretch the shortened groups. The result should be better balance of the muscular tensions with better posture of the particular segment. An example might be forward shoulders where the pectorals have become unduly shortened and the rhomboids too relaxed. The corrective work would concentrate on lengthening the pectorals and shortening the rhomboids."

Phelps and Kiphuth (9) in their book, *The Diagnosis and Treatment of Postural Defects,* make several suggestions for determining whether or not a person has forward shoulders. They suggest checking the distance between the scapulae. Looking down from above a person and observing the line from the tip of the shoulders to the sternum below the clavicle is presented as a method of determining forward shoulders. When the shoulders are in their normal position, this line should be practically straight, but when shoulders are forward, it becomes concave.

Kraus (6) in *Principles and Practice of Therapeutic Exercises,* states the following: "Pectoralis Muscles: An angle of less than 170° to 180° indicates a shortened pectoralis muscle group, which is usually associated with an anterior displacement of the shoulder, . . . and possible dorsal kyphosis."

Katherine Wells (11) in her dissertation, *A Manual of Kinesiology,* states that when arms are hanging passively, they show a slight inward rotation at the shoulder joint, causing the palms to face to the rear.

Keeping these suggestions in mind, a group of tests was set up, measuring shoulder position and pectoral muscle tightness.

Procedure

All of the girls enrolled in McPherson College, McPherson, Kansas, for the school year 1953-54 for 12 semester hours or more were selected for this study. There were 124 subjects with age range from 18 to 33 years, with a mean age of 19.6 years. Age, height, and weight were recorded by each

individual as well as data on any injury or defect which might affect her posture, especially in the shoulder area. However, since there were no serious deviations from the normal position of the shoulder area, all cases were retained.

Tests which were selected from the literature for use in determining "round shoulders" were the palm test, measurement of the distance between the scapulae, the shoulder line test, and the chest angle measurement. Two tests were used for measuring pectoral tightness: the pectoral stretching test was to measure the degree of forced extension when arms are in an abducted position; and the table test to measure the degree of pectoral muscle tightness, with passive hanging of the arms.

Equipment

The boxwood carpenter's rule and a protractor were used for all the measurements taken in degrees except the standing pectoral stretching test. The instrument used for that test is illustrated in Figure I. It consisted of a vertical bar at the back, capable of being adjusted according to the height of the girl being tested. At the top of the vertical bar, were two horizontal bars, with pieces of calibrated metal. There was a stationary pointer which was perpendicular to the horizontal bars when straight. As the bars were moved back by the arms, the calibrated metal pieces moved under the stationary pointer, so that degree readings could be taken.

Administration of Tests

All measurements were taken under the following conditions. Subjects were asked to remove their clothing to the point where there was no limitation to observation or movement of the shoulder area, and all measurements were taken for both sides of the body. They were taken at no particular time of the day, but at the convenience of the subjects. All measurements were taken by the author of this study, as an attempt was made to administer all tests with as little variance as possible.

Description of Measurements

Palm Test. The subject was asked to stand in a normally erect, but relaxed position, and the position of the palms were observed from the front. Palms were considered to be in a normal position if facing medially, and were recorded normal. Any position of the palms posterior to the above was recorded in one of the following ways: very slightly back, slightly back, some back, or back. The estimate of posterior position was a subjective measurement.

Distance Between Scapulae. The subject was asked to remain in a normally erect, but relaxed position. The distance between the scapulae was measured at the height of the acromion process of the shoulder joint and again three inches below that point.

Shoulder Line Test. The subject was instructed to sit on a stool in a position which felt normally straight, with arms relaxed at the sides. The subject was

observed from above in order to note the line from the tip of the shoulders to the sternum below the clavicle. The result which was estimated subjectively was recorded as follows: normal, very slightly concave, slightly concave, some concavity, or concave.

Chest Angle Measurement. The subject remained seated on the stool, with arms hanging relaxed at the sides. The apex of the boxwood carpenter's rule was placed on the center of the sternum in line with the shoulder joints. When the shoulder was in a straight line with the sternum, it was considered the neutral point of measurement (180°). If the shoulders were posterior to the sternum, the angle measurement was recorded above 180°. If the shoulders were anterior to the sternum, the measurement was read below 180°. The angle reading was taken by placing the rule on a protractor.

Pectoral Stretching. The subject was asked to stand on the base of the instrument shown in Figure I. The instrument was adjustable, so that the center

FIGURE I. Administration of Pectoral Stretching Test.

of the horizontal bars was placed between the scapulae in line with the center line of the upper arm when held in a horizontal position. The subject was instructed to bring both arms to a horizontal position outward at the sides, palms facing forward, and to raise the lower arm at the elbow so that it was in a vertical position. The subject was then asked to bring the arms back as far as possible, without raising or lowering the elbow. The

elbows were touched slightly during the arm extensions, as shown in Figure I, to give the feeling of keeping the upper arm in a horizontal position to prevent lowering of the elbows. If the subject hyperextended the back, she was reminded to move only the elbows back. However, some hyperextension did not affect the measurement, as there was some flexibility in the vertical bar of the instrument, so that the whole instrument moved back and the result still measured arm extension.

The neutral point of measurement (0°) was considered to be when the arms were straight out with no movement back. The degree of extension was read above 0°. The readings were taken when the subject had reached maximum effort. Occasionally an accurate reading of the arm movement was difficult, because the scapulae at the center of the instrument caused movement of the horizontal bars so that the angle of movement of the arms could not be accurately determined. This occurred in 13 cases, and they were not used in final computations.

Table Test. The subject was asked to lie on a narrow table (bench) on the back. She was then asked to straighten the arms out from the shoulders, palms up, and allow the arms to drop as far as possible, keeping them in the same plane of movement. The bench was narrow enough that it did not restrict movement. The apex of the boxwood rule was placed on the shoulder joint. One arm of the rule was placed along the center of the upper arm, and the other stabilized along the top of the shoulder line. With a 180° angle considered to be with the arms parallel to the floor, this angle was read above 180° on each arm.

Statistical Procedures

Reliability of the measurements used in this study was determined by repeating all measurements on the first 26 subjects. Each subject was given all tests consecutively, and at a different time was tested again. Records of measurement were recorded on charts, separate charts being used for the two sets of measurements for reliability. The Pearson Product Moment method of correlation was used on each test, and where tests included both sides of the body, correlations were computed for each. The reliability coefficient was low on one side of the body in the case of the Table Test, so the remaining 98 subjects were measured twice on that test. They were given the Table Test first, then again after completing the other tests. The reliability was then computed using the larger group of subjects on the Table Test. When the distance between the scapulae was used in computation, an average distance of the two measurements were used.

Correlations and t tests of significance of differences were computed.

Analysis of Data

A Pearson Product Moment correlation was computed for the first and second measurements of each of the tests which were administered to the first 26 subjects. The reliability coefficients of the tests were $r = .80$ or

above, as shown in Table 1. Therefore the tests were retained for further study.

TABLE 1
Test Reliability Coefficients

Test	Number of Cases	r
1. Average Distance Between the Scapula	26	.80
2. Chest Angle Measurement	26	.86
3. Pectoral Stretching Test		
Left	26	.86
Right	26	.84
4. Table Test (Sum)		
Left	98	.89*
Right	98	.89*

*Stepped up by the Spearman-Brown Prophecy Formula.

TABLE 2
Inter-correlations Among Tests

Tests	1	2	3	4
1. Average Distance Between the Scapula				
2. Chest Angle Measurement	.57			
3. Pectoral Stretching, Left	.01	.21		
4. Pectoral Stretching, Right	.26	.21		
5. Table Test, Left	.22	.04	.49	
6. Table Test, Right	.13	.08		.59

The Pearson Product Moment method of correlation was used between tests, as shown on Table 2. The coefficients which show significance are between the Chest Angle Measurement and the Average Distance Between the Scapulae; the Pectoral Stretching Left and the Table Test Left; and the Pectoral Stretching Right and the Table Test Right.

The Chest Angle Measurement and the Average Distance Between the Scapulae were both measurements of stationary shoulder girdle position. According to the result ($r = .57$), if there is a small degree of angle (just above 180°) across the chest, there will be a greater distance between the scapulae, comparatively. The other two tests showing correlation—Pectoral Stretching and Table Test—for both sides of the body, had to do with arm extension in an abducted position, which would pull on the pectoral muscles. The results ($r = .49$ and $r = .59$) show that these tests were measuring approximately the same thing—tightness of the pectoral muscles.

Since there were no other significant correlations, it would appear that there was little correlation between tests measuring stationary shoulder girdle position and those measuring pectoral muscle tightness.

Since the data were not continuous on the Concavity of Chest Test and the Palm Tests, findings were grouped in categories as stated earlier in Description of Measurements. The only significant result was between the Shoulder Line Test and the Chest Angle Measurement (8.35). Again, there appeared to be a significant relationship between these two tests of the stationary shoulder girdle position. As shown in Table 3, t tests of significance of differences between the Shoulder Line Test and Means of Average Distance Between the Scapulae were then computed. The t test between the normal group and the group, very slightly concave, was 2.53, which is significant at the 2 per cent level of confidence.

TABLE 3

T Test of Significance of Differences Between Shoulder Line Test (Means of Average Distance Between the Scapulae)

Group	No. of Cases	Mean	Standard Deviation	t ratio	5% Level of Confidence
Normal	27	4.76	.81		
				2.05	1.96
Very Slightly Concave	35	5.11	.53		
				1.01	1.96
Slightly Concave	35	5.25	.49		
				.10	1.96
Some Concavity	15	5.23	.61		
				.82	2.06
Concave	12	5.46	.76		

Summary and Conclusions

The purpose of this study was to determine the relationship between tightness of the pectoral muscles and "round shoulders." Attempt was made, therefore, to determine the degree of forward shoulders and the amount of tightness in each individual tested. Correlation coefficients were not significant between these two areas.

On the basis of this study, the following conclusions have been drawn:

1. Tightness of the pectoral muscles, as found by the Pectoral Stretching and Table Tests, was not found to correlate significantly with "round shoulders," as measured by the Average Distance Between the Scapulae and Chest Angle Measurement Tests.

2. The Chest Angle Measurement, Shoulder Line Test, and the Distance Between the Scapulae, all appear to measure stationary shoulder girdle positions.

3. The Pectoral Stretching Test and the Table Test appeared to be good tests measuring tightness of the pectoral muscles.

It is recommended that a similar study be made on college men. Differences in development of the pectoral muscles may cause different results.

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Personal Health Knowledge of College Students Before Instruction

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Abstract

A standardized personal health knowledge test was given as a pretest to 12,000 freshman and sophomore students in 15 scattered universities, colleges, and junior colleges. A 25 per cent sample was analyzed to determine the health knowledge of students before instruction in college hygiene classes. The results were significant, showing health ignorance, both student-recognized and unrecognized, to be widespread, especially among junior college students, with considerable differences between institutions. Mean test section scores, as well as item scores, showed great variation, demonstrating the need for pretesting as an aid to sound planning of health instruction.

FROM 1951 to 1957, the writer conducted a study to learn what college freshman and sophomore students know about personal health. The main purposes of the project were: (a) to determine the general level of personal health knowledge among college students before instruction in college hygiene classes; (b) to discover those areas of personal health knowledge in which instruction is particularly needed; (c) to gather additional data to extend the pretest norms for the test used in the study.

The Dearborn College Health Knowledge Test[1] was used. This standardized test has a mean reliability coefficient of .89 (split-halves method with Spearman-Brown correction) (3), and a mean coefficient of correlation of .75 between retest scores and final grades given in hygiene courses. Its item validity is assured by the manner of selection and the approval of the test items by a "jury" of health educators, physicians, and related experts (1, 2). The test was administered under standardized conditions as specified on the test copy and in the manual of directions. In order to distinguish between unrecognized student ignorance and recognized student ignorance, the instruction was given to complete as many items as possible but to leave a blank rather than to make a wild guess.

The test was given as a pretest in beginning health education classes, preponderantly freshman students, in 15 universities, colleges, and junior colleges scattered over the nation. These institutions included five California junior colleges, Santa Barbara Junior College, College of the Sequoias, Ventura Junior College, San Francisco City College, Santa Monica City College; and ten scattered four-year colleges and universities: California State Poly-

[1] Terry H. Dearborn, *College Health Knowledge Test.* Stanford University Press, Stanford, California, 1950. A standardized test composed of 100 multiple choice items (five alternative) grouped into 11 sections covering the area of personal health.

technic College (San Luis Obispo), University of Southern California, University of California at Los Angeles, Santa Barbara College of the University of California, Washington State College, University of Kansas City, Longwood College (Farmville, Virginia), Stephen F. Austin State College (Nacogdoches, Texas), University of Wichita, and Pennsylvania State University. Usable reports covering 12,000 students were obtained over a six-year period. A 25 per cent random sample of 3,000 cases was selected for detailed study including section, item, and distractor analysis.

Findings

The results of the section and item analysis are presented in Table 1. Separate columns for combined junior colleges, and for the universities and four-year colleges combined, are provided in order to show the differences in achievement discovered on these two levels. A column is provided also for the per cent blanks on each item in order to distinguish between recognized and unrecognized student ignorance.

Reference to Table 1 will provide the reader with the mean pretest scores made, in the 15 institutions, on any item and on any of the 11 sections appearing in the College Health Knowledge Test.

Table 2 presents a comparative analysis showing the considerable range of section and item scores, individual student scores, and the range of mean total scores among the participating institutions.

Summary and Conclusions

1. As measured by the Dearborn College Health Knowledge Test, there is a consistent and significant difference in health knowledge achievement (9.9 points) between the junior colleges and the universities and four-year colleges combined,[2] although the students were all of lower division level, mostly freshmen.

2. The mean achievement scores of only 44 per cent and 54 per cent clearly demonstrate the need and responsibility to make health instruction available on the college level, and to improve such instruction in high school.

3. College students recognize their ignorance in some areas of personal health information, are justifiably confident of their understanding in others, but cling to much misinformation in still others. They scored high and left few blanks, only 3.7 per cent, among the items dealing with social and biological background for health. By contrast, in the section dealing with reproduction and heredity the section score and test score are similar but nearly 13 per cent of the misses were blanks rather than errors, indicating their recognition of ignorance in this area. On the other hand, in the lowest scoring section, exercise and body mechanics, ignorance is not only great but is also unrecognized by the student, for the mean blanks were only 5 per cent.

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[2] Data for the university and the four-year college levels were initially handled separately, but were combined when it was found that their mean scores differed by less than one point.

TABLE 1

Sectional and Item Analysis of Health Knowledge of 2,400 Students in Ten Colleges and Universities, and 600 Students in Five Junior Colleges

Test Section and Item Number	Per Cent Responses Correct		Per Cent Left Blank, All Institutions
	Colleges and Universities	Junior Colleges	
A. Social and biological background			
1	70	71	1.7
2	57	59	.7
3	53	45	5.7
4	56	44	5.0
5	48	35	7.5
6	60	44	1.5
Section mean	57	50	3.7
B. Nutrition and diet			
7	63	53	.8
8	49	32	9.0
9	64	42	7.2
10	52	39	16.0
11	53	42	3.0
12	51	46	1.7
13	65	58	.8
14	29	16	1.0
15	62	37	5.7
16	64	45	9.0
17	43	29	13.9
18	80	66	1.5
19	73	47	1.7
20	29	10	3.0
21	62	45	11.0
Section Mean	56	40	5.7
C. Excretion and cleanliness			
22	67	45	11.7
23	59	63	.8
24	15	11	5.5
25	29	29	5.7
26	80	79	1.0
27	75	61	2.2
Section mean	54	48	4.5
D. Exercise and body mechanics			
28	71	70	.5
29	37	45	2.7
30	47	40	8.0
31	66	47	9.7
32	41	29	2.0
33	25	13	11.4
34	23	8	9.2
35	13	8	3.7

TABLE 1. *Continued*

Test Section and Item Number	Per Cent Responses Correct		Per Cent Left Blank, All Institutions
	Colleges and Universities	Junior Colleges	
36	63	43	.8
37	51	37	1.7
Section mean	44	34	5.0
E. Fatigue and rest			
38	75	61	7.5
39	19	32	13.2
40	64	53	5.2
41	89	74	1.0
42	80	76	.3
43	44	47	2.0
Section mean	62	57	4.9
F. Mental hygiene			
44	26	24	8.2
45	41	40	9.0
46	53	47	11.2
47	72	58	10.0
48	36	35	2.7
49	77	63	1.5
50	60	61	5.7
51	47	32	13.7
52	30	29	10.2
53	55	58	1.2
54	58	55	1.5
55	39	42	1.7
56	48	42	.8
Section mean	49	45	6.0
G. Reproduction and heredity			
57	70	61	1.7
58	19	11	10.5
59	55	40	18.4
60	67	45	11.4
61	42	29	12.2
62	16	8	37.6
63	61	42	16.7
64	81	76	4.0
65	88	84	1.0
66	72	45	19.2
67	55	29	14.4
68	46	29	14.4
Section mean	56	42	12.6
H. Prevention and control of disease			
69	67	55	8.5
70	69	71	2.2
71	78	67	3.7

TABLE 1. *Concluded*

Test Section and Item Number	Per Cent Responses Correct		Per Cent Left Blank, All Institutions
	Colleges and Universities	Junior Colleges	
72	63	47	1.7
73	79	71	4.5
74	48	42	10.2
75	76	63	1.5
76	23	13	8.0
77	84	71	2.5
78	60	45	4.5
79	48	37	9.5
80	46	24	21.4
81	63	40	12.2
82	41	37	7.7
Section mean	64	50	7.0
I. Hygiene of Special organs			
83	74	48	6.2
84	58	45	7.5
85	17	5	13.4
86	69	68	1.2
87	82	68	2.0
88	27	11	17.2
Section mean	55	41	7.9
J. Hygiene of environment			
89	64	63	2.0
90	60	55	6.5
91	44	32	17.4
92	75	68	6.2
93	65	58	3.0
Section mean	62	58	7.0
K. The use of medical care and advice			
94	54	45	6.2
95	5	5	2.0
96	52	53	5.0
97	39	24	5.5
98	71	58	4.2
99	66	47	9.0
100	46	42	3.0
Section mean	47	39	5.0
Mean score for total test	54.4	44.5	6.6

4. The range of mean total scores among different institutions, up to 21 points, indicates considerable variation in health knowledge achievement from secondary schools in different parts of the nation, and an opportunity and responsibility for colleges in low-scoring locations to help remove such deficiencies.

TABLE 2

Comparative Analysis of Health Knowledge Achievement Among 3,000 Freshman and Sophomore Students Before Collegiate Instruction

Data Analyzed	Colleges and Universities	Junior College
Mean total score, all institutions combined	54.4	44.5
Range of mean scores among institutions	59.6 - 50.3	61.2 - 40.3
Range of mean section scores	64 - 44	58 - 34
Range of item scores	89 - 5	84 - 5
Range of individual student scores	95 - 17	94 - 13
Percentage of items missed by majority of students	37	65

5. The range of mean section scores, 20 points for colleges and universities and 24 points for junior colleges, shows a wide variation in the knowledge possessed among the several health topic areas, which should be taken into consideration by every hygiene instructor in planning the subject matter, time allotment, and emphasis in his course. Thus, the junior colleges have their highest mean section score, 58 per cent, for the area of hygiene of environment, but only 34 per cent for the area of exercise and body mechanics. The colleges and universities have a high mean score of 64 per cent for the section on prevention and control of disease, and their lowest score, 44 per cent, for the section on exercise and body mechanics.

6. The wide range of mean item scores, some 80 points, demonstrates that there are tremendous differences in the possession of sound information not only between section areas but also among the various specific concepts and facts within a given area. The item analysis, and the tabulation and analysis of the distractor alternatives within the low-scoring item, is a necessary first step toward the identification and removal by the instructor of the ignorance or fallacy responsible for the low score on any particular item.

7. The wide range of individual student test scores, some 80 points, indicates the striking differences in health knowledge achievement among different individuals having completed their high school education. The lower end, 13 per cent, is convincing evidence that a better job needs to be done for health education in our nation.

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Effect of Increasing Back and Abdominal Muscle Strength on Low Back Pain[1]

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Abstract

The method of approach for relief of chronic recurrent backache in women, as described in this study, was the development of muscle power in the abdominal and back musculature through use of a program of progressive resistance exercises. Two groups of subjects were used in the investigation; an experimental group, composed of 19 subjects who complained of painful back symptoms, and a control group consisting of 27 subjects who were free from back pain and abnormality. The results of the study revealed a definite relationship between chronic backache and the strength of the abdominal and back musculature. Symptomatic relief was evident as muscle hypertrophy and power increased.

THE LOWER PART of the back is one of the most common sites of musculoskeletal pain. Low back pain is a manifestation of a great variety of local and general disturbances and is one of the most difficult complaints for which to determine proper cause and treatment.

Authorities (1, 11) in the area of orthopedics estimate that between 80 and 90 per cent of all backaches may be attributed to faulty mechanical and postural habits which aggravate lumbar and sacral back structures by placing undue stress and strain on them. Abdominal and back muscular imbalance, abdominal muscle weakness, and general trunk muscle weakness are also factors which may contribute to back pain and are often secondary to poor body mechanics and postural habits as well as to illness, lack of exercise, obesity, and congenital anomalies.

The treatment of low back pain is not universally the same. However, it is quite generally agreed that persons suffering from chronic remittent low back pain need very careful and persistent care in promoting muscle development, maintaining good posture, and practicing correct body mechanics. The exercises for the trunk musculature should consist of a muscle strengthening routine which promotes rapid development of muscles to their maximum capacity.

It is a generally accepted fact that muscle strength can be significantly augmented only by contracting against resistance which is great enough to call

[1]This study was made in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Physical Education in the Graduate College of the State University of Iowa, August 1955.

for maximum effort of all muscle fibers in a given muscle. As strength develops, this resistance must be proportionately increased to assure as a final result maximum development of a muscle group. This is the basic physiological principle upon which progressive resistance exercises are based.

Purpose of the Study

The purpose of this study was to investigate the response of abdominal and back muscles in women to progressive resistance exercises. More specifically, an attempt was made to determine: 1. the average strength in selected trunk muscle groups of normal individuals and of those individuals who were suffering from backache; 2. the amount of strength which could be developed in the trunk muscles of both groups, and to determine if this increase was significant; 3. the length of time it took to develop maximum strength in the trunk muscles for both groups; 4. the ratio of back muscle strength to abdominal muscle strength in both the experimental group and control group at the beginning and at the end of the exercise program; 5. the time in the exercise program when those suffering from back pain observed a relief or decrease of symptomatic pain; 6. the percentage of the experimental group who found relief from pain.

Terminology

Maximum strength—The level of muscular development in the abdominal and back extensor groups beyond which it seems impossible to develop greater strength.

One-lift maximum—The heaviest weight which can be lifted one time only.

Ten-lift maximum—The heaviest weight which can be lifted ten times only.

Progressive resistance exercises—Synonymous term is heavy resistance and low repetition exercises. DeLorme (2, *p. 210*) provides the following succinct definition: "Progressive resistance exercises are exercises in which the resistance to contraction is progressively increased commensurate with the patient's muscle power."

Review of Literature

There is universal interest shown in the low back pain problem. The principles of the application of heat, massage, corrective exercises, analgesic blocking, and immobilization are the generally accepted essentials of a conservative regime in the treatment of acute low back symptoms.

Only a very small number of the studies investigated mentioned the use of progressive resistance exercises for increasing trunk muscle strength. The usual procedure described was one in which the number of repetitions in performing a specific set of exercises was gradually increased.

A pilot study was carried out under the direction of Dr. Carroll Larson in 1949 at the University of Iowa. Forty-five white, male patients complaining of low back pain were given a course of progressive resistance exercises similar to the one described in this study. Ninety-six per cent of the cases were relieved of symptoms at the completion of their program.

Dr. Kraus (8, 9, 10) studied and evaluated 4,000 cases of low back pain. He found that, in all cases, trunk muscular imbalance and weakness were present in varying degrees. His method of treatment, along with massage, heat, artificial supports, and postural correction, was a program of exercises which were gradually increased in difficulty and number of times performed, and in some cases, in an attempt to increase resistance, an undetermined load of weights was held in the patients' hands.

The use of the overload principle has assumed increasingly greater importance in the professional and medical literature. High resistance exercises have proved to be an invaluable technique, in many cases, for obtaining rapid increase of muscle strength in the wide variety of patients seen in the clinics of large general hospitals, and in physical education training programs.

DeLorme (2, 3, 4, 5) may be credited with developing a program of exercises for the increasing of muscle power in a limited time. Other writers have used modifications of DeLorme's technique of procedure. Zinovieff (15), McGovern (13), MacQueen (12), Hoag (7), Watkins (14), and others attempted to find a method of performing resistance exercises which would produce the most rapid muscle development without undue strain on the joints and ligaments involved.

Their modifications were concerned with decreasing the number of repetitions of the exercise, increasing the resistance, and determining the number of exercise bouts per week which would give the most beneficial results. The results of their studies agreed that progressive resistance exercises had proved to be of practical value in developing muscle power and hypertrophy.

Procedure

Two groups of subjects were used in this study. The experimental group consisted of 19 women between the ages of 16 and 36 who were suffering from certain types of chronic back pain. These subjects were referred by Dr. Carroll Larson, orthopedic surgeon, Children's Hospital, State University of Iowa. Measurements were taken on 21 subjects in the experimental group for the initial measurements, however, and these readings were included in the before-exercise mean but not in the gain or after-exercise means. The control group consisted of 27 college women students who were considered to be free from back pain or any back abnormality. The ages of this group ranged from 18 to 35.

Dynamometer and one-lift maximum strength tests were given to the flexor and extensor trunk muscles of each subject before and after the exercise program. The individualized day-by-day treatment consisted of performing exercises against a prescribed graded resistance supplied by a pulley weight arrangement. The amount of resistance was determined by the near maximum lift or by a load which could be lifted correctly but with marked effort ten times. This weight was employed until strength improvement necessitated an increase in load, which occurred about once weekly. Each treatment period consisted of ten trunk flexion exercises (knees bent and feet supported); ten

back extension exercises (hands clasped behind neck); and ten additional trunk flexion exercises. The subjects were asked to report three times weekly at appointed times and to continue their treatment until they had reached their maximum strength development. If a subject was unable to lift any greater weight the prescribed times for at least six consecutive exercise periods, it was assumed that she had reached her maximum in strength development.

The exercises were performed on a specially designed table (see Figure I) with the pulley and weight arrangement attached to the wall at the rear of the

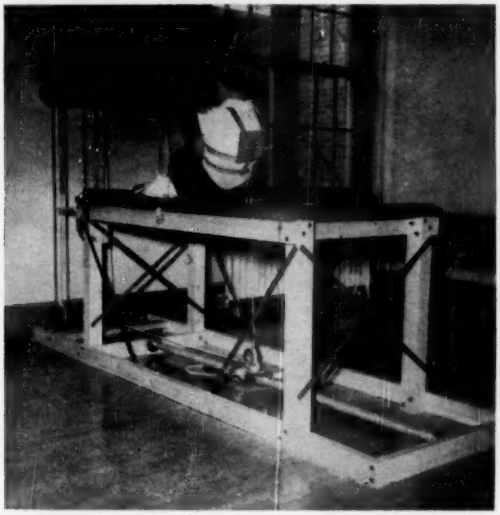

FIGURE I. Exercise Table, Pulley Weight Arrangement, Vest-Harness, Trunk Flexion Exercise.

table. Through the center of one end of the table top was a slot through which the rope from the pulley could be attached to the "vest-harness" worn by the subject. The table top was also hinged at one end and in the middle and free at the other end so that it could be elevated in the center, pyramid fashion, to permit correct body position when performing the back extension exercises (see Figure II).

This table was used for the dynamometer and one-lift maximum tests. The dynamometer (see Figure III) was enclosed in a push-pull apparatus which was attached to a movable metal collar fitted around the pipe at the base of the table. Running from the dynamometer through the slot in the table was one chain which could be snapped to the hook on the "vest-harness."

Records of dynamometer and one-lift maximum readings were carefully kept on each subject. Also, a day-by-day record was maintained throughout the study on each person. These records included repetitions of exercises performed and the amount of weight lifted each time. On the individual record

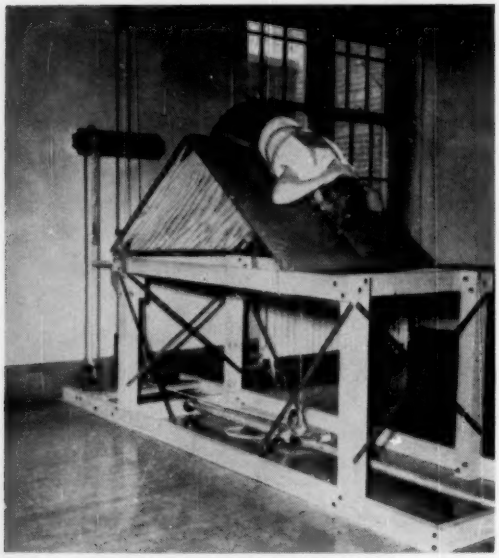

FIGURE II. Back Extension Exercise.

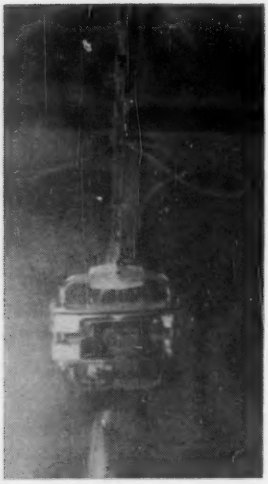

FIGURE III. Dynamometer and Push-Pull Apparatus

sheets, data were maintained of the subjects' reaction to the exercises, personal feelings of improvement, discomfort, and other responses.

Individual graphs were made for each of the 46 subjects to determine her performance as demonstrated by weekly ten-lift maximum measurements.

The data were treated statistically in the following manner:

1. Initial and final means of maximum trunk flexor and back extensor muscle group strength measurements were computed for the control group and the experimental group, using both the dynamometer and the one-lift maximum readings.
2. Means were computed for the gains or differences between the initial and final measurements for the abdominal and back muscle strength for both groups using dynamometer, one-lift maximum, and ten-lift maximum readings.
3. Tests of the difference between the experimental and control group means for the initial dynamometer and the one-lift maximum readings were computed.
4. For each test, t's were computed to determine the significance of the difference of gain from the initial to the final test of the back and abdominal strength using the dynamometer and one lift maximum readings.
5. A test of the difference between the control and experimental groups mean gains were computed for the trunk flexor and trunk extensor strength using both the dynamometer and one-lift maximum readings.
6. For each group, ten-lift maximum means were computed every fourth exercise period.
7. Measures of central tendency for back strength/abdominal strength ratios were computed for each group before and after the exercise program using the scores from the dynamometer and one lift maximum tests. The coefficients were obtained by dividing the back strength measurements by the abdominal strength readings.
8. Pearson product-moment correlation coefficients were computed between the dynamometer and one-lift maximum measurements of back extension and trunk flexion. The scores for both groups were combined for the initial test and for the final test.

Analysis of Data

The average length of treatment was 12 weeks for the subjects in both groups with a mean of 26 total exercise periods per subject. The individual graphs revealed that, as a whole, there was a consistent gain of muscular strength for the back extensors and trunk flexors. There were temporary declines and plateaus plotted which did not show a fixed pattern in relation to where they appeared on the curve for the different subjects. The maximum strength development mean for both groups was shown by the graphs to be on the 25th exercise period and in the 12th week.

Table 1 contains the means of the maximum measurements recorded before and after the exercise program. A definite gain was shown by each group in the three measurements taken for the abdominal and back muscle strength. In all cases except the after-treatment of dynamometer reading for back extension, the experimental group had lower scores in both the initial measurements and final measurements.

TABLE 1

Means of Maximum Measurements Before and After Exercise Program

(Experimental Group)

Measurement	Before Exercise Mean	After Exercise Mean	Difference Between Means
N	21	19	
Dynamometer[1]			
Back	95.27	138.68	43.11
Abdominal	20.52	32.74	12.22
One-lift maximum[1]			
Back	32.64	64.09	31.45
Abdominal	5.07	18.62	13.55
Ten-lift maximum[1]			
Back	24.96	54.22	29.26
Abdominal	1.39	14.98	13.59
(Control group)			
N	27	27	
Dynamometer			
Back	106.59	136.26	29.67
Abdominal	29.48	36.70	7.22
One-lift maximum			
Back	40.92	68.30	27.38
Abdominal	6.52	21.11	14.59
Ten-lift maximum			
Back	36.03	63.62	27.59
Abdominal	3.06	18.58	15.52

[1]On this and all following charts the values for dynamometer readings are in kilograms and those for one- and ten-lift maximum are in pounds.

The t scores and the mean differences in strength when compared to the S. E. of the differences presented in Table 2 reveal that the gains made in abdominal and back muscle strength by each group were significant.

The t scores (Table 3) resulting from the difference between the control and experimental groups' initial measurements and also from their mean gains of muscular strength showed no significance.

Table 4 shows the measures of central tendency for back strength/abdominal strength ratios. For the dynamometer readings, the mean ratio for all the subjects in the experimental group before treatment was 6.49 as compared with 4.70 for the control group. The after-readings show the tendency for each group to decrease this ratio as shown in the mean of the after-exercise ratios of 4.71 for the experimental group and 4.01 for the control group. The after-exercise ratio of 4.71 for the experimental group is the same as the before-exercise ratio for the control group.

The extremely large ratio for the one-lift maximum may be due to the large number of 0 measurements which were recorded for the initial trunk flexion measurements. To compute the ratios, it was necessary to change the zero to a value of one.

TABLE 2

The Difference and Standard Error of the Difference Between Initial and Final Tests

Test	Experimental (N=19)			Control (N=27)		
	Mean Gains	S.E. Difference	t[1]	Mean Gains	S.E. Difference	t[2]
Dynamometer						
Back	41.58	8.05	5.17	30.00	4.61	6.51
Abdominal	11.63	2.65	4.39	7.19	1.73	4.16
One-lift maximum						
Back	31.67	2.70	11.73	27.00	2.57	10.51
Abdominal	13.50	1.39	9.71	14.58	1.32	11.05

[1] 1 per cent level of significance for 18° of freedom is 2.878.
[2] 1 per cent level of significance for 26° of freedom is 2.2779.

TABLE 3

A. The Difference Between Means of Initial Measurements of the Experimental and Control Groups

Measurement (N=48)	$M_e - M_c$	S.E. Difference	t[1]
Dynamometer			
Back	11.02	31.76	.35
Abdominal	8.96	8.49	1.06
One-lift maximum			
Back	8.28	11.48	.72
Abdominal	1.45	2.42	.60

[1]5 per cent level of significance for 46° of freedom is 2.012.

B. The Difference of Gains Between Experimental and Control Groups

Measurement (N=46)	$M_e - M_c$	S.E. Difference	t[1]
Dynamometer			
Back	11.58	13.88	.83
Abdominal	4.44	4.16	1.07
One-lift maximum			
Back	4.67	9.69	.48
Abdominal	1.08	4.76	.23

[1]5 per cent level of significance for 44° of freedom is 2.015.

The frequencies of the ratios at the beginning of the exercise program for both the experimental and control groups were extremely scattered. The final distribution for these groups was more homogeneous and there was a definite concentration of ratios between 2.00 and 4.99. The range and mode on Table 4 summarize these points.

TABLE 4

Measures of Central Tendency of Back Strength/Abdominal Strength Ratios for Both Groups Before and After Exercise Program

Group	Dynamometer		One-Lift Maximum	
	Before (N=21)	After (N=19)	Before (N=21)	After (N=19)
Experimental				
Range	1.00-27.99	2.00-10.99	1.00-38.99	2.00-7.99
Mean	6.49	4.71	12.06	3.71
Median	4.35	4.13	8.35	3.55
Mode	2.50	3.50	4.50	3.50
	4.50		8.50	
Control (N-27)				
Range	1.00-22.99	2.00-7.99	1.00-58.99	2.00-5.99
Mean	4.70	4.01	13.97	3.44
Median	3.93	3.93	7.50	3.38
Mode	4.50	4.50	5.50	2.50

Pearson product-moment correlation coefficients presented in Table 5 reveal that the relationship between the two tests for back extension was significant at the 1 per cent level at both the initial and final testing periods and the rela-

TABLE 5

Correlation Coefficients Between Dynamometer and One-Lift Maximum Measurements of Both Groups Combined

Combined Groups	Before Exercise (N=48)	After Exercise (N=46)
Abdominal	.32*	.23
Back	.63*	.58**

*5 per cent level of significance for 45° of freedom is .288.
**1 per cent level of significance for 45° of freedom is .372.

tionship between the two abdominal tests at the initial testing period was significant at the 5 per cent level of confidence.

There was very little relationship shown between the dynamometer and one-lift maximum coefficients for the after-exercise abdominal strength measurements. This may be attributed to the difficulty of performing sit-ups against dynamometer resistance in correct form without bringing in hip flexors. This was very difficult to do when the degree of movement was nearly zero. When performing the one-lift maximum test, the subject could assume a curled position before beginning her pull against maximum resistance.

Relief from painful back symptoms was reported by all but two subjects in the second week after the third or fourth treatment. This relief in some cases was complete; in others, it was only partial. Those patients who had partial relief continued to experience gradual alleviation from severity and frequency of painful symptoms as their exercise programs progressed. Simultaneous to the report of relief from pain, it was observed that the patients had a definite increase in abdominal muscle strength and a decrease in back strength/abdominal strength ratio.

At the termination of the individual exercise programs, 58 per cent or 11 patients had complete relief from back pain, 31 per cent or 6 had partial relief and 11 per cent or 2 had no relief (see table 6). Five of the six patients who received only partial relief did not complete their programs of exercise. Similarly, the two subjects who received no benefit from their exercises did not

TABLE 6

Number and Per Cent of Subjects Receiving Relief from Back Pain

Relief (N=19)	Number	Per Cent
Complete	11	58
Partial	6	31
None	2	11

reach a point of maximum strength development. One subject was very irregular in attendance, missing one or two weeks at a time. The other subject was released because of the increased pain and discomfort she felt immediately following the exercises.

Conclusions

The evidence presented in this study supports the following conclusions:

1. A significant increase in abdominal and back muscle strength may be attained by use of a systematic program of progressive resistance exercises.
2. The back strength/abdominal strength ratios may be decreased by developing maximum power in the trunk muscles.
3. It is evident that back extension is a stronger movement than trunk flexion as indicated by the back strength/abdominal strength ratios.
4. Under the foregoing conditions it appears that:
   (a) By increasing the power of the back and abdominal musculature, symptomatic relief from chronic recurring low back pain may be obtained.
   (b) Relief from chronic, painful low back symptoms may be felt when the strength imbalance between the back extensors and trunk flexors is reduced.
5. The dynamometer and one lift maximum tests are equally effective in measuring the strength of back extension.

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(Submitted 6/19/57)

Study of Psychic Stress in Freshman College Women[1]

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Abstract

The effect of a psychic stressor on depth perception, steadiness, blood pressure, and simple hand-eye co-ordination was investigated in freshman college women. The results were compared with the manifest anxiety scores of the subjects. It was found that a psychic stressor significantly influenced scores with regard to blood pressure, depth perception, steadiness, and hand-eye co-ordination, but with the exception of blood pressure the change in scores was not directional. The Taylor Manifest Anxiety scores of the individuals did not appear to be correlated with stress scores obtained for other tests.

STRESS, in its physiological meaning, is the rate of wear and tear on the body caused by agents, conditions and situations which tend to destroy the homeostatic balance. Selye (20, 21, 22) and others have sought to explain the adaptation of the body to stressors as it strives to maintain its homeostatic balance.

Stressors may be physical, social, or psychic in nature. However, the human organism in reacting to the stressor and resolving the stress does not differentiate among the stressors. Stress appears to be stress, regardless of the nature of the stressor.

In terms of physiological response, stressors elicit circulatory change, metabolic change, temperature change, and body chemistry change in the individual (2, 15).

It is apparent that stress affects behavior (2, 4, 5, 6, 7, 11, 22). It also appears that the overt effects of stress are related to the subjective state of the individual to such an extent that the subjective state of the individual may largely determine the stressfulness of the situation.

The Taylor Test of Manifest Anxiety (14, 23) is based upon the assumption that variation in drive which is related to internal anxiety or emotional anxiety can be ascertained by a pen and pencil test. It has been reported (3, 8, 9, 11, 12, 16, 17) that anxiety level affects intellectual functioning, visuomotor control and the level of aspiration index. Since anxiety is a psychic stressor, the manifest anxiety level could foretell performance.

As an overt, physical manifestation of the effect of a stressor on performance, the steadiness test (1, 13, 18) has been used to determine individuals' reactions to differential stress.

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The ability to appreciate or discriminate the third dimension, to judge distance and to orient oneself in relation to other objects in the visual field has been demonstrated to be related to individual adjustment (16) and hence it may be postulated that depth perception could be related to varying bodily responses to stress.

Grollman (10), Schneider and Zangari (19), and others have all indicated that psychic stressors increase the cardiac output, pulse rate, blood viscosity, and blood pressure. Hence, even when there are no overt behavioral patterns indicating stress, the individual may still be making a physiological adjustment to a stressor.

There has been a great deal of research done on the reaction of the individual to physical stressors, both physiologically and psychologically; however, the effect of psychic stressors on behavior and on physiological response has just begun to be measured.

Procedure

Subjects. A total of 28 subjects was used. All were freshman women majors in physical education at the Woman's College of the University of North Carolina, Greensboro, North Carolina. The subjects ranged in age from 17 to 19 years. All were in a state of good health and had been approved for activity by the college physician.

Instrumentation. The blood pressure was measured by a Tycos Aneroid Manometer manufactured by the Taylor Instruments Companies. All counts were taken by the same investigator; the count was taken three times in each instance and an average of the three counts recorded.

Depth perception was measured by means of the Howard Dohlman depth perception apparatus manufactured by C. H. Stoelting Company. This apparatus requires the subject to line up two poles evenly with one another. This was done at distances of five and ten feet.

Steadiness was tested by the C. H. Stoelting apparatus. This is standard apparatus for testing arm, hand steadiness. There are ten holes of varying diameter on a metal block. The task is to insert the stylus in the hole without making contact with the edge of the hole. In this test, the subject was allowed to rest her elbow on the table and the one-eighth inch hole with a 30-second hold was utilized. All contacts were recorded on an electric counter which was placed in circuit with the stylus and the block.

Experimental Conditions. The Taylor's Manifest Anxiety Test (23) was administered to the group at the first testing period. It was explained by the administrator that the test was a test of personality and serious thought should be given all answers. Throughout the course of the experiment the term "anxiety" was not mentioned.

During the second testing period the subjects were measured with regard to blood pressure and steadiness.

The third testing period was used for measurement of depth perception. In addition, a simple hand-eye co-ordination test was administered. In this

test a tennis ball was thrown at a wall from a distance of ten feet. The subject was required to stand in a space three feet by three feet and had to throw the ball against the wall above a line three feet six inches from the floor. The throw and subsequent catch had to be done with one hand and that hand had to be the same for both the throw and the catch. Three trials of 30 seconds each were given. If the ball was missed, the subject was required to make the recovery herself.

During the second and third testing periods each subject performed under the supervision of the investigator. No comments were made and an effort was made to have no one, other than the tester, observe the subject and her test results. Silence was maintained throughout the tests.

A repetition of testing periods two and three followed for the fourth and fifth testing sessions. The only difference in testing periods four and five from two and three was the introduction of a psychic stressor situation. The subjects had been told previous to the testing periods that the physical education staff (their teachers) and some of the graduate students were interested in the individual test results of the freshman physical education majors. During these sessions, six to ten members of the physical education staff and several graduate students observed the tests and appeared to take notes on the subject's progress. The observers commented to each other on the tests and the subjects in voices which were audible to the subjects.

Measurements

For each subject the Taylor Manifest Anxiety Test was scored. Three measures of systolic and diastolic blood pressure were taken at each of the two testing times. Three measures of steadiness were taken at each of the two testing times. Three measures of depth perception at ten feet and three measures at five feet were taken for each subject during each of the two testing times. The wall test involving hand-eye co-ordination was administered three times to each subject during each of the two testing times.

Analysis of Data

The experiment was designed to investigate *differences* in individuals as a result of a psychic stressor. It would have been possible to analyze the raw scores, the range and mean of which are reported in Table 1, but since the primary interest was in changes and significance of changes, the raw scores of most variables under pre-stress and during-stress conditions were converted by subtracting the pre-stress raw score from the during-stress raw score and using the difference as a base of analysis. This "difference score" is called the *stress score* and the mean difference and significance of these scores is reported in Table 2.

It is to be noted that the stress scores of the subjects were significant with regard to blood pressure, depth perception, steadiness, and the wall test in indicating that the psychic stressor was of sufficient magnitude to elicit a differential response within the individual. It is especially interesting to note that, with the exception of blood pressure, this differential response was

TABLE 1

Pre-Stressor and During Stress Ranges, Means, and Standard Deviations for Blood Pressure, Depth Perception, Steadiness, and Wall Test

Test	N	Pre-Stressor			During Stress		
		Range	Mean	σ	Range	Mean	σ
Blood pressure	28						
Systolic		138-98	115.71	9.31	146-106	124.43	3.20
Diastolic		88-50	69.21	7.93	110- 60	77.07	10.49
Depth perception @ 10 ft.	28						
Total score		8-191	41.93	42.43	3-137	34.18	22.56
Best score		0-58	8.07	11.82	0-25	5.64	6.36
Mean score		3-41	13.96	12.65	1-46	11.43	9.84
Depth perception @ 5 ft.	28						
Total score		0-49	14.68	9.97	3-61	17.96	12.49
Best score		0-12	2.71	2.72	0-12	3.21	3.27
Mean score		0-16	4.93	3.37	1-30	6.29	5.52
Steadiness Test	28						
Total score		0-54	3.71	7.91	0-34	4.21	9.33
Wall test	23						
Total score		68-25	52.17	12.73	71-35	54.52	9.13
Best score		24-9	19.26	3.43	25-15	20.04	1.40
Taylor's M.A.		4-35	16.64	7.74			

TABLE 2

Mean Difference of Change and Significance of This Change Under Stress on Blood Pressure, Depth Perception, Steadiness, and Wall Test

Test	N	Mean Difference	t	Level of Confidence
Blood Pressure	28			
Systolic		11.3928	3.7995	1%
Diastolic		9.9642	4.5726	1%
Depth perception @ 10 ft.	28			
Total score		28.5714	4.0472	1%
Best score		7.2141	3.5690	1%
Mean score		9.6071	4.0649	1%
Depth perception @ 5 ft.	28			
Total score		9.7857	5.2679	1%
Best score		2.7142	5.6949	1%
Mean score		3.2857	3.9326	1%
Steadiness test	28			
Total score		3.1785	2.8397	1%
Wall test	23			
Total score		6.6956	8.7630	1%
Best score		1.7391	4.3143	1%

not directional in nature. As reported in Table 3, there was no significant directional change resulting from the introduction of the psychic stressor except in the case of blood pressure. Blood pressure, systolically and di-

astolically, had a tendency to rise when the individual was subjected to the stressor and this rise was significant at the 1 per cent level of confidence.

As can be seen in Table 4, which indicates the number and percentage of subjects showing differences, a significant number of subjects evidenced

TABLE 3

Mean Difference and Significance of Directional Change Under Stress on Blood Pressure, Depth Perception, Steadiness, and Wall Test

Test	N	Mean Difference	t	Directional Change
Blood Pressure	28			
Systolic		9.25	3.1981*	Increase
Diastolic		8.1071	3.3124*	Increase
Depth perception @ 10 ft.	28			
Total score		−7.8571	.8901	Decrease
Best score		2.4285	1.0036	Increase
Mean score		−2.5357	.8564	Decrease
Depth perception @ 5 ft.	28			
Total score		2.5	.9804	Increase
Best score		.4285	2.0140	Increase
Mean score		− .1071	.1021	Decrease
Steadiness test	28			
Total score		.3929	.2820	Increase
Wall test	23			
Total score		2.3478	1.5263	Increase
Best score		.7391	1.4156	Increase

*Significant at 1% level of confidence.

TABLE 4

Percentage of Subjects Showing Increased/Improved or Decreased/Poorer Scores on Blood Pressure, Depth Perception, Steadiness, and Wall Test Under Stress

Test	N	Increased/Improved		Decreased/Poorer		No Change	
		N	%	N	%	N	%
Blood pressure	28						
Systolic		20	71	5	18	3	11
Diastolic		21	75	4	14	3	11
Depth perception @ 10 ft.	28						
Total score		10	36	15	54	3	11
Best score		15	54	12	43	1	3
Mean score		10	36	15	54	3	11
Depth perception @ 5 ft.	28						
Total score		17	61	11	39	0	0
Best score		12	43	13	46	3	11
Mean score		10	36	14	50	4	14
Steadiness test	28						
Total score		9	32	9	32	10	36
Wall test	23						
Total score		14	61	8	35	1	4
Best score		11	48	7	30	5	22

change in all of the tests when the stressor was introduced, but the *directional change* was usually evenly balanced between the increased/improved and the decreased/poorer.

The findings indicating the directional increase in blood pressure during the alarm reaction to a psychic stressor are in accord with knowledge concerning the general adaptation syndrome. Specifically, Grollman (10) and Schneider and Zangari (19) indicated that this directional pattern of blood pressure might be expected if the stressor was of sufficient intensity to elicit the stress response.

The Taylor Manifest Anxiety scores, which ranged from 4 to 35, were investigated with regard to their relationship to the variables. The top six anxiety scores were compared with the lower six anxiety scores with regard to systolic and diastolic blood pressure change by means of an analysis of variance. It was found that, although there was a difference between the two groups of subjects when they were divided into the anxiety extremes, this difference with regard to blood pressure was not significant. The results of this analysis may be found in Table 5.

TABLE 5

Summary of Analysis of Variance of Systolic and Diastolic Blood Pressure Scores for "Less" and "More" Anxious Subjects

Source of Variation	df	Sum of Squares	Mean Square	F
Between groups	1	121.5	121.5	2.0976
Between conditions	1	0	0	
Total within	21	1216.33	57.92	

The Taylor Manifest Anxiety scores were then correlated by means of the Pearson r with the stress scores for blood pressure, depth perception, steadiness, and the wall test. There was found to be no significant correlation between the Taylor Manifest Anxiety scores and any of the performance or physiological differences. The correlation table is reported in Table 6.

It is to be noted that, although there was a fairly wide range in the Taylor Manifest Anxiety scores, not one of the subjects fell into the classification which Taylor is willing to indicate may signify a tendency for anxiety. Thus, all subjects either had a tendency toward lack of anxiety or were well within the normal anxiety pattern of the average person. This may shed light on the lack of significance found in the correlations and variance. There is always the possibility that anxiety does not correlate with the variables measured, but there is also the distinct possibility that the paucity of "anxious" subjects obscured any significant pattern which may exist.

Conclusions

It was found that the psychic stressor employed elicited a response in the subjects which was significantly different from the response found within the subjects when the psychic stressor was not employed. In the case of depth

TABLE 6

Coefficients of Correlation Between Scores on the Taylor Manifest Anxiety Test and Stress Scores in Blood Pressure, Depth Perception, Steadiness and the Wall Test

Test	N	r
Blood pressure	28	
Systolic		.2287
Diastolic		—.1527
Depth perception @ 10 ft.	28	
Total score		.0975
Best score		.0186
Mean score		.1159
Depth perception @ 5 ft.	28	
Total score		.1370
Best score		.0957
Mean score		.0667
Steadiness test	28	
Total score		.1099
Wall test	23	
Total score		.3918
Best score		—.0943

perception, steadiness, and hand-eye co-ordination, this change was not directional in nature. The change in blood pressure, however, was directional. Blood pressure was elevated in response to a psychic stressor.

There is reason to postulate that this differential reaction in individuals as a result of exposure to a psychic stressor may be interpreted many ways through performance. However, a predictable physiological stress reaction is always elicited, which demands that some adaptation be made. Thus, the individual attempts to resolve the stress encountered through his physiological adjustment and his differential performance patterns.

Such an interpretation of psychic stressors might prove to be of great importance in a class situation when the student is under observation during any testing period. A significant change in performance might be anticipated by the teacher but whether that change tended to improve or hinder the performance score would be difficult to predict. However, regardless of the performance pattern, the physiological reaction to stressors with regard to blood pressure would be essentially the same in the majority of individuals. Specifically, an increase is evidenced.

With regard to the manifest anxiety level of the individual as measured by the Taylor Manifest Anxiety Test, it was noted that there did not appear to be any relationship between anxiety and blood pressure, depth perception, steadiness, and simple hand-eye co-ordination. It is possible that a lack of subjects with a strong tendency for anxiety may have obscured any relationship; if, indeed, one does exist.

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Cholesterol Studies: A Review

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Abstract

As a result of cardiovascular diseases and associated handicaps, the American public has become increasingly aware of its fitness. However, this fitness problem involves the question of cholesterol. There follows a condensed summary of the role cholesterol has in human function and suggests its possible relationship in an exercise program as well as to factors of the cardiovascular system, age and sex, heredity, diet, obesity, changes in weight, and smoking.

CHOLESTEROL IS an interesting and somewhat mysterious and perplexing substance. It appears in all bodily tissues and is especially abundant in the brain and spinal cord. Most tissues can synthesize cholesterol, and ounce for ounce, the adrenal gland seems most efficient (41). Substantial amounts of cholesterol are synthesized with an efficient chemical mechanism for delivering it to the tissues by way of the vascular system. It would, therefore, appear that cholesterol carries out some vital function. When cholesterol is utilized in the body, the chemical pathways followed are little understood. It appears that the liver oxidizes cholesterol more actively than other tissues (41). If there exists a direct function for serum cholesterol to perform, it has not yet been discovered, although serum cholesterol evidences itself in harmful roles in the hardening of the arteries and associated cardiovascular diseases (10, 18, 19, 20, 21, 39, 41, 47).

The father of cholesterol chemistry is Adolf Windaus of Germany, now 77 years old, retired, who built up the world's leading school of sterol chemistry at the University of Gottingen (10). Windaus started with cholesterol because this component had been isolated as early as 1770 and partly because it was the most easily obtainable of all steroids. He and his associates formulated the structure of this molecule and later derived from cholesterol vitamin D_1, D_2 and D_3, all active agents against rickets (10). Steroid hormones are also derived from cholesterol.

The Cholesterol Question

The big question and unsolved problem involves the function of cholesterol. Cholesterol seems to be the essential building material for the bile acids, steroid hormones, and vitamin D_3 (10, 41). Why does the body produce large amounts of cholesterol? Is cholesterol perhaps just an incidental by-product of the manufacture of the hormones and vitamins? There are indications that cholesterol causes circulatory problems, as it is frequently found

deposited along the wall of blood vessels in victims of hardening of the arteries and of atherosclerosis.[1]

Page, *et al.*, (43) mentions in a recent atherosclerosis report that "evidence is presented to suggest a possible general association with high fat consumption, but it is difficult to disentangle this from caloric balance, exercise, changes in body weight, and other metabolic and dietary factors that may be involved."

Physicians as a group have contented themselves in the past to treat the effects of the disease instead of looking into the basic cause or causes of the deadliest enemy, vascular insufficiency (42). Page and Corcoran (42) estimate that, in this branch of disease, science lags 50 years behind its research upon numerous other diseases of man. Although there are many institutes, hospitals, or laboratories devoted to cancer, infantile paralysis, and tuberculosis, only a few are devoted to this vascular disease.

Physical education researchers to date have not published any reports on cholesterol levels in relation to fitness. However, as one investigates the literature of vascular diseases and the part physical fitness plays as a role, he becomes convinced that physical educators have a contribution to make, a contribution which could be developed in the next ten to 20 years if sufficient attention is given to research in this area. Scientific research by all connected fields of science, with a sobering collaboration of data sowing the seeds for skillful living, should in time produce the quintessence of longevity.

Vascular System and Cholesterol

Windaus (52) analyzed various diseased aortas and reported that there was six times as much cholesterol and 20 times as much esterified cholesterol in the atherosclerotic aorta as observed in the normal aorta. Windhaus (51), Schoenheimer (45), along with Meeker and Jobling (35), carried on similar investigations and concluded that the proportion of lipids in aortas increased with age.

Leary (30) substantiated earlier work establishing a direct causal relationship between serum hypercholesterolemia and atherosclerosis. Lerman and White (31) observed that in individuals who had experienced myocardial infarction prior to the age of 40, the serum cholesterol was higher and the basal metabolic rates were lower than in suitable controls.

Gertler, Garn and Lerman (11) studied the differences between a control group, coronary disease group, and a matched control group considering: (a) cholesterol ester, total cholesterol; (b) free cholesterol; (c) phospholipids on 97 men who experienced coronary heart disease and 146 healthy non-hospitalized men of comparable age. Their investigation showed that the group with coronary heart disease exceeded the two control groups in values

[1] *Atherosclerosis* is concerned with the condition of the larger blood vessels and actually is a form of arteriosclerosis in which there is a hyperlasis of the outer layers of the involved arteries and degeneration of the elastic layer. *Arteriosclerosis* is a general term to all forms of thickening of the arteries.

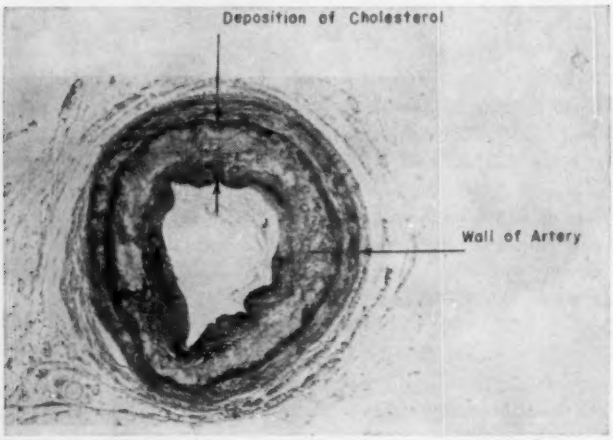

FIGURE I. Cardiac Coronary Artery. The intima is greatly thickened and contains pale regions of deposition of cholesterol and nearly acellular connective tissue. Magnification, 13×. (Modified, Eli Lilly & Co.)

of serum cholesterol (total, free and esterified) and in serum phospholipids. The greatest difference was found in serum cholesterol esters, while a somewhat smaller difference was found in free cholesterol. This demonstrates that in coronary heart disease the higher total serum cholesterol reflects the altered level of the esterified fraction. The total cholesterol and phospholipids ratio between the coronary disease group and the two healthy groups indicates a disturbance in lipid inter-relationships in coronary heart disease.

Elevations (15) of blood serum cholesterol have a useful application in epidemological studies of coronary heart disease and may be somewhat useful as possible predictors with many other kinds of observations, such as diastolic blood pressures and age.

Cholesterol Standards for Humans

Keys (18) discussed the constancy of serum cholesterol measurements and reported that for clinically healthy persons there are large differences in serum cholesterol between individuals of the same age. In addition, the individual tendency is relatively constant as the mode of life is held constant (18). This suggests that a change of living habits, which could be either dietary and/or physical exercise (shifts in metabolism level), could alter the serum cholesterol picture.

Keys, Anderson, and Mickelsen (27) made a comparative study of total serum cholesterol concentrations in basal and nonbasal states. In a systematic study on men, serum cholesterol was ascertained from blood samples drawn in the basal state and again two hours after a breakfast of fruit, cereal with cream and sugar, two slices of toast with butter and jam, and coffee

with cream and sugar. In group B series, 10 gm. of pure cholesterol was mixed with scrambled eggs replacing the cereal.

In A and B groups the men were inactive after breakfast and showed a slight rise in cholesterol level. The mean change was 2.41 per cent of the basal value in A and 1.83 per cent of the basal state for B, results which are significant statistically. In group C, which took moderate vigorous exercise (walking on treadmill) after breakfast, there was no serum cholesterol rise, but instead a tendency to fall below the basal level. The slight rise in serum cholesterol after breakfast in the sedentary subjects Keys explains as a possible reflection of lipoproteins complying with the demand for transportation of the newly ingested fats. But, when physical activity is engaged in during this absorption period, the improved circulation, in addition to nutrients being withdrawn from the blood to meet the ascending metabolic needs, causes a lower serum concentration of lipoproteins and likewise cholesterol.

Mean differences (mg./100ml.) nonbasal minus basal cholesterol values in clinically healthy men. All nonbasal bloods drawn 2 hours after breakfast. In series A and B, the subjects were sedentary between samples, but in series C, they did physical work. In series B, breakfast included 10 gm. of added cholesterol (27).

Series	*N*	*Mean Differences*	*S.D.*	*S.E.*
A	51	4.92	11.72	plus 1.66
B	73	3.95	11.74	plus 1.37
C	15	—3.93	12.95	plus 3.34

In summary, Keys mentions that the difference in cholesterol concentration in basal or nonbasal blood when drawn in the morning is so small that for most comparative studies it may be neglected if the nonbasal subjects are active physically. Keys furthermore states that "these results suggest a reason for part of the difference in susceptibility to coronary heart disease that is reported in comparisons between active and inactive men" (27). Morris (37) substantiates this.

Peters and Man (44) show the range in total serum cholesterol levels from 123 to 274 mg. per 100 ml.; this study substantiates Keys' reports. Since among normal healthy men there exist wide differences in fitness measures, and hereditary inheritance, dietary habits, and exercise levels along with other environmental conditions; the differing levels of cholesterol among people present a complex problem.

Cholesterol Age and Sex

There seems to be a parallelism between the age trend of cholesterol concentration in the serum and the age trend in atherosclerosis (12, 22, 23, 44). Actually, atherosclerosis is not a part of the aging process, as there is an accompanying loss of muscle tone, in conjunction with constriction of the blood vessels. Excessive growth of connective tissue in muscular layers, or the unnatural deposition of extraneous material within the inner layers of the ar-

terial wall, are pathological changes, *not a consequence of normal aging.* As these changes occur, the blood vessels narrow and become rigid, a condition which is generally called arteriosclerosis or hardening of the arteries. Other terms are applied to this disease, dependent upon the location and type of degenerative changes. Generally, a combination of types occurs (6, 26).

At the age of 25 the mean serum cholesterol level among populations living on high-fat diets is about 50 mg. per 100 ml. higher than those on low fat diets, but whereas this difference rises irregularly in the former to 75 mg. per 100 ml. at about the age of 50, no such increase in the serum cholesterol level with age occurs in the latter (22).

The diets of infants and children have long been offered as proof against the relationship between cholesterol ingestion and atherosclerosis. It has become increasingly clear, however, that the age of the subject plays an important role in his response to a cholesterol diet. This does not necessarily mean chronological age *per se,* as investigators have pointed out that *physiological age* and *chronological age* do not always go hand in hand. With age comes changes in some habits, usually withdrawal from activity as loss of fitness develops.

Sperry and Webb (46) reported the influence of aging on serum cholesterol by re-examination of some 22 individuals, 14 men and 8 women, 14 years after the first observation was made. A rise in the concentration of serum cholesterol of 22.7 per cent occurred in the women whose mean age at the time of the first test was close to 31 years. This rise was similar for the men.

Keys (25) showed that maximal serum cholesterol appears a decade later in life in women than it does in men. This is evidenced in Lewis, *et al.,* (32), whose report found that for both sexes at the age of 20 the cholesterol levels are similar. Both sexes have a rise from this age but it is greater for men than for women. However, at the age of 50 the rise for women is higher than men and continues so with the series reported.

Epstein and Boas (9) found that adult women did not attain the cholesterol level of men until ten years their senior. However, ages above 50 in women manifested similar characteristics to men in cholesterol levels. Women with conditions of atherosclerosis had higher cholesterol value than men of corresponding age and condition. This substantiates Keys' report.

Page and Corcoran (42) state that the incidence of coronary disease up to the age of 40 is approximately four times as great in men as in women. After 40 it levels off and is practically equal. This follows cholesterol differences with sex and age, substantiating Keys, Epstein, and Boas. Page and Corcoran believe that this leveling off process is due to the greater proportion of female sex hormones present in women before menopause (42).

Cholesterol and Heredity

Adlersburg (1) has given evidence that families with case histories of coronary atherosclerosis suggest hereditary disturbances. Page (41) in reviewing

the work of Glass, points out that genes rarely produce absolute effects, but that they do determine an individual's capacities and the nature of his reaction under specific conditions. Hereditary and environmental factors coexist, but one is not exclusive of the other. Page and Corcoran (42) recognize that the inheritance of the kind of blood vessels with their filter qualities determines to a considerable extent their range of function.

Sprague, Gertler, and Garn cited by Page (41) suggest that individuals with predominant muscularity, compactness, and "maleness," the so-called mesomorphic types, are most likely to have an early onset of coronary atherosclerosis. It is believed possible that diet and *other measures* can prevent early deterioration in this group.

Cholesterol and Diet

Keys reports on 64 normal healthy middle-aged men who changed their dietary cholesterol intake by 50 per cent. The changes on serum cholesterol had no effect as the reported table below indicates (18).

No. of Men	*Diet Chol. Change*	*Serum Chol. Before*	*mg./100ml. After*
23	Plus	245	246
41	Minus	241	244

It would be easy to assume from these results that diet does not alter blood serum cholesterol levels. This is not completely true. Twenty-one men in another investigation were fed on the rice-fruit diet usually used in the treatment of hypertension cases. With these normal men, serum cholesterol fell an average of 26 per cent in three weeks. Men with the higher initial serum values tended to have a greater decline. The response was rapid in descent and continued at a steady pace for several weeks until a new level was attained.

Mean serum cholesterol values, in mg./100ml., before and after three weeks of subsistence on the rice-fruit diet. Men grouped according to initial serum level (18).

No. of Men	*Before*	*After*	*Change in %*
7	200	160	—20
7	239	160	—33
7	417	252	—35

In a normal person's diet, it is not the cholesterol in the food that is of major importance but the total number of calories supplied (18, 28, 39). Cashin and Moravok (3) indicated the harmful effects of fat ingestion at high levels. Page and Corcoran (42) state that "if the amount in the diet (fat) were the only factor controlling blood lipids, the problem of keeping them at a reasonably low level would be relatively simple. But the body not only receives cholesterol and fat from food; it manufactures them as well. The complete restriction of dietary lipid leads to increased synthesis in the body." Indications along similar lines were shown by Walker and Wier (50)

who studied for a four-week period 27 overweight hospitalized patients placed on a reducing diet of 600-800 calories. There were at the end of this period 12 who lost 2-4 pounds per week showing a drop of 4.4 mg./100 ml. of serum cholesterol. Fifteen who lost 4 or more pounds per week showed a somewhat greater drop of 14.7 mg. Many fears concerning rapid weight reduction have been based on the concept that fat stores in the body are relatively stable, and weight reduction would necessarily cause increased fat mobilization with consequent elevation of blood cholesterol since it is one of the chief vehicles of fat transport. Many indications point to the fact that body fat deposits are in a constant state of dynamic change with a daily turnover many times greater than would be burned during a period of starvation. These patients undergoing rapid weight reduction as a result of rigid calorie restriction did not manifest an elevated total plasma level. This report of Walker and Wier must be accepted with caution since the investigation was performed on hospital patients who were in the process of undergoing surgery or medical treatment. In addition, it must also be brought to light that the ordinary daily sedentary activities were not permitted.

Swanson, *et al.*, (48) determined blood serum cholesterol levels in 184 midwestern healthy women whose ages ranged from 18 to 94. Upon determination of dietary intake over a seven-day period, they concluded that there seemed to be no significant relationship to intake of fat and protein to concentration of total blood serum cholesterol.

Mann, *et al.*, (33) suggest that a heavy caloried intake over a long period of time elevates serum cholesterol levels and contributes to atherosclerosis. Page, *et al.*, (43) also reports that diet may play an important role in the pathogenesis of atherosclerosis.

There is a non-parallelism between dietary intake and energy output as a person grows older. It is a known fact that as people live longer many become progressively less active. Dietary intake habits change little as one grows older. Intake needed in the youunger and more active years, when kept rather constant throughout life, many times contributes to a progressive chronic disorder in later years. Actually, the most common form of nutritional unbalance is obesity (47). Obesity is a nutritional failure that consumes more energy than one expends (32). The problem here is largely one of self-discipline from the standpoint of food intake and one of energy output (exercise) and for better balance of fat metabolism.

Cholesterol and Obesity

Overweight in adults is a condition that prevails and its incidence is increasing in men and, to a lesser degree, in women (36). Hundley (17) indicates that evidence is incomplete in some respects, but it seems clear that substantial health gains would result if obesity could be either prevented or remedied in an appreciable number of the population. It is estimated about one-fifth of adults over 30 years of age are *sufficiently overweight* (10% or more) to affect their health (36). Obesity is more than twice as prevalent in

the United States as is abnormal underweight (47). However, with the incidence of obesity there seems to be no direct evidence that it causes less chance for survival, as reported by a Mayo Clinic study (2) of over 3,000 coronary patients who evidenced no complications, 35.0 per cent of whom lived. There were 377 of these patients who were obese; their decade survival was 44.4 per cent. In a five-year follow-up, 70 per cent of the obese patients were alive while only 38.9 per cent of the non-obese survived. It is quite possible that other factors are involved which may have considerable influence on survival.

There is much evidence that men who are engaged in vigorous work are less prone to cardiovascular disorders than sedentary men (38). Many men of the latter group tend to be truly obese. Lewis, *et al.*, (32) report that cholesterol levels are higher in overweight groups than those of normals. Keys (24) gives some figures on relative weight and serum cholesterol.

Serum Total Cholesterol Concentration, in Mg. per 100 ml. in Clinically Healthy Minnesota Men of the same age but Classified Accroding to Relative Body Weight as Per Cent of Standard Average for Height and Age. Means and Standard Errors

Relative Weight	*Serum Cholesterol*
Less than 95%	222.7 ± 4.7
95% - 105%	228.0 ± 5.9
More than 105%	225.1 ± 6.6

Avoidance of obesity appears to some researchers to be an effective prophylaxis to atherosclerosis (8). Although it is not altogether applicable, correction of obesity as a preventative measure in persons with elevated cholesterol has value (13).

Cholesterol and Smoking

Hammond and Horn (16) reported that death rate owing to cardiovascular disease is significantly higher than in older men 50-59 years of age who are regular cigarette smokers than those who never smoked. Gofman, *et al.*, (14) made an interesting investigation into the relation of cigarette smoking, serum lipoproteins, and coronary heart disease and came up with meaningful relationships. They found that men who never smoked had as a group lower average cholesterol than those who smoked.

Gofman and his associates in summarizing their investigations state, "Whether or not the association of lipoprotein elevation with cigarette smok-

	Men 20-29 yrs.		*Men 30-39 yrs.*		*Men 40-59 yrs.*		*Women 18-39 yrs.*	
	N	*Chol.*	*N*	*Chol.*	*N*	*Chol.*	*N*	*Chol.*
Never smoked	55	205.2	56	226.5	17	259.9	33	201.5
Less than 10 cigarettes per day	10	239.1	12	216.6	9	250.5	9	190.8
10 to 19 cigarettes per day	23	208.6	24	226.3	18	229.1	13	190.8
20 or more cigarettes per day	37	226.4	67	235.3	44	255.1	8	217.0

[Extracted from tables 1, 2, 3, and 4 (14)].

ing entirely accounts for the higher incidence of coronary disease mortality in smokers, we can say it must account for an appreciable portion of it. This would justify intensive effort to learn more about the mechanisms through which the lipoprotein elevation associated with smoking arise and also the interesting age trends noted in the association" (14). This might suggest that the "effect of smoking on the cardiovascular system" parallels the "effect of cholesterol on the cardiovascular system."

Moutis (40) reported on this controversial problem of smoking on 36 college students whose cardiovascular measurements, although not quite statistically significant, indicated that in quiet tests on the Cameron Heartometer, the 17 smokers showed higher pulse rates, systolic blood pressure, and systolic amplitude of the brachial sphygmograph pulse wave. Although these residual smoking effects were studied on young men between 17 and 19 years of age, substantially greater deteriorative effects might be evidenced in older men who have smoked a greater number of years. This would suggest that impairment in circulation as a result of smoking in some way causes less utilization of lipoproteins. It is more difficult to develop improved circulation among smokers. Therefore, it would be difficult to reduce their cholesterol levels. Such a projected inference warrants investigation.

Cholesterol and Exercise

Dawson was one of the first authorities to suggest exercise as a therapeutic agent as well as a preventative measure for circulatory diseases. His phonetic description is given verbatim both as evidence and for the appreciation of his writing style.

> Patients with arterial sclerosis wer placed upon a see-saw & gradually tipt up and down. Their symptoms, confusion & hedake, & their objectiv signs, color & mental condition, wer improved. Thus, one is led to ask, Mite not these gentle oscillations be duplicated in lite calisthenics & mite not the latter tend to prevent as wel as alleviate the condition? (7)

Following Dawson 12 years later, Cureton (4) in discussing the causes of cardiovascular disease, reviewed the work of Dock who reported that the degeneration of arterial walls was caused by fatty deposits, a wax-like substance called cholesterol. Cureton suggested that "protein food, vitamin E and exercise seem to give the body power to burn up some of the excess cholesterol contained in our blood" (4). Lean (ectomorphic) types probably have greater circulatory efficiency with their thin coronary walls than those who are fat (endomorphic). The lean types appear to burn up their body fat and serum cholesterol faster than other body types. "The implication would also seem to be that exercise, more persistently used by all types, would help reduce fat and cholesterol but the value of exercise has not as yet been precisely demonstrated by research. It seems to be a promising problem for investigation" (4).

Fixed habits over a period of time are no doubt contributory to an individual's fitness status. As people grow older, they become progressively less

active. Less activity should mean less food intake. However, since food habits stay rather constant, they cause increasing over-nourishment, and coupled with decreasing activity, lead toward malnourishment. This negative relationship appears logical, as obesity emerges as the most common form of nutritional imbalance. The problem is not aging but one of self-discipline which should begin in youth and continue throughout life to control exercise and diet for effective balance. Stieglitz (47) ends his nutrition report with the significant statement "that the most important and significant universal (fitness) fertilizer is the sweat of effort."

Exercise has both immediate and long-range effects upon the circulation. The blood vessels that carry on this circulation process play the role of filters for the plasma, and the fluid penetrating the vessel wall passes out into the tissues. When the cells in the tissues have withdrawn the material required, the remaining fluid returns to the bloodstream as lymph. This completes the cyclical filtration of the blood plasma by the blood vessels. This transporting system of the lymph and its subsequent return to the blood is a highly efficient carrying agent for the transportation of large quantities of fat and cholesterol. "Exercise aids in keeping the cycle active and possibly also aids in preventing particles of fat from becoming stuck in the blood vessel wall filter" (42).

An important factor that contributes to atherosclerosis is the presence of high blood pressure (or hypertension). This non-normal increase of pressure causes more residue to be deposited on the filter beds of blood vessels. As a result, people with such increases of pressure develop atherosclerosis at a greater rate and earlier in age than persons with blood pressures that are normal (8). It has been shown that in non-diseased persons their blood pressures may be normalized through a program of exercise (5).

An interesting statement was made at a panel meeting held at the New York Academy of Medicine at which Kendall stated much information has been obtained on how cholesterol enters the blood stream (ingestion) but that nothing is known about its removal. He further estates that the final cholesterol level is determined "by the ability of the cells throughout the body, muscle cells in particular, to utilize and dispose of cholesterol presented to them (8). *This suggests that exercise is needed to influence the level of cholesterol metabolism.*

At another symposium, Carlson, a physiologist, stated that "continuous physical and mental labor" (50) appeared to be an important agent in resistance to cardiovascular degeneration.

Keys, *et al.*, (29) grouped early surveys of various blood serum cholesterol data and endeavored to separate cases according to degrees of physical activities and concluded that within some populations men who were in heavy manual labor tended to have somewhat lower blood serum cholesterol values. It also appeared that habitual diet had more influence on total serum cholesterol values. This report used broad survey terminology to place individuals into light, medium, and heavy work groups and also used reasonable dietary

consumption estimates. It should be noted that the claim for habitual diets is no doubt true but it is likewise true that people tend to have habitual exercise or non-exercise patterns.

Mann, *et al.*, (32) brings forth related evidence regarding exercise upon cholesterol. Central Americans (33) who consumed much food but had small body frames with low serum cholesterol levels maintained high energy expenditures by their mode of life. The conclusion according to Mann was that the effect of muscular exercise would in some way control the regulation of serum cholesterol levels. It was felt that, since the excess food consumed by North American adults led to fat deposits, exercise might divert these food excess deposits to expendable energy by exercise pathways and thereby keep the cholesterol level at a more nearly normal level.

During one week in which they followed their usual daily activities, four healthy young men were fed at a research diet table which, by adjusting their diet, maintained their body weights. Then their daily caloric intake was doubled with fat content held constant at control level. The subjects were required to maintain their weight within 5 lbs. by strenuous daily exercises for four weeks. This high energy exchange period was facilitated by increasing gross surface heat losses as a result of engaging in swimming, running in bursts of speed, basketball, and outdoor cycling. During this period, the subjects slept longer and more soundly and claimed to be able to work at their studies more efficiently. They claimed to feel better, more relaxed, and "rugged." With double caloric intake plus the exercise, the serum cholesterol levels averaged somewhat less than at the initial control level.

Keeping the double caloric intake but discontinuing the exercise for three weeks during which they took part in the control level of activities, the subjects gained weight with a marked increase in serum cholesterol levels. During this period the subjects became "fat," their shirt collars and belts became tight, complexion became sallow, and they complained of fitful hours of sleep. The final two weeks were for weight reduction as the calories were reduced with dietary fat held constant and exercise at initial control level. There appeared no real serum cholesterol changes as a result of dietary caloric decreases for the two weeks studied. During this period, the subjects complained of poor efficiency at their studies; they felt tired and irritable.

The results showed that a large increase in food supply did not raise serum cholesterol levels as long as exercise dissipated the surplus energy. "There seems little doubt that significant effects can be produced on both the body composition and the serum lipids in most subjects by this alteration of diet and physical activity" (32).

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Effects of Tournament Stress on Electrocardiograms of United States Olympic Free Style Wrestlers

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Abstract

Electrocardiograms were recorded from a group of wrestlers who participated in the tournament to select the 1956 United States Olympic Free Style Wrestling Team. Four subjects whose electrocardiograms were normal at rest showed no marked electrocardiographic changes as a result of competition. A single subject whose resting electrocardiogram presented the Wolff-Parkinson-White syndrome following competition showed electrocardiographic changes consistent with those of the wrestlers whose tracings were normal. A single subject showed electrocardiographic changes following competition suggestive of subendocardial abnormality.

PHYSICAL effort has been observed to cause temporary changes in the electrocardiogram. Most of the studies of this type have been made on runners or on subjects walking on a treadmill. It was the purpose of this investigation to study the electrocardiographic changes in a group of athletes during and following participation in a wrestling tournament.

Review of the Literature

Much of the literature dealing with the effect of exercise on the electrocardiogram has been reviewed in a previous paper[1] and need not be repeated here.

Bazett (2) reported that the QRS complex and the P-R interval may be temporarily lengthened immediately after exercise, a phenomenon which he attributed to slower conduction as a result of fatigue. Paterson and Paterson (9), who studied the electrocardiograms of a group of athletes immediately after competition in a 31-mile walking marathon, reported that the P-R and QRS intervals were unchanged in most of the tracings, that the height of the T waves was increased in the records of all but one competitor, and that the height of the P waves was either increased or remained constant.

Hoogerwerf (6) observed that in marathon runners the height of the R, S, and T waves was decreased immediately following a race. Cooper, O'Sullivan,

[1]Rasch, Philip J., H. Stanley Cowell, David D. Geddes, and Eugene R. O'Connell, "An Electrocardiographic Study of United States Olympic Free Style Wrestlers," *Research Quarterly*, **29**: 46-53, March 1958.

and Hughes (4) noted that the amplitude of the R and T waves in the electrocardiograms of two subjects increased greatly after playing a game of squash. In an electrocardiographic study of oarsmen, they observed an increase in the amplitude of the P waves, especially in lead II, after a mile of rowing. Reindell (11) is said to have demonstrated that in the fatigued state following strenuous athletic activity there was an increase in the amplitude of the P waves. Barker, Schrader, and Ronzoni (1), whose subjects exercised by running up and down stairs until they experienced pronounced dyspnea and fatigue, stated that the R waves changed little; however, the T waves tended to become much taller in all three limb leads but returned to near normal within five to ten minutes after exercise.

According to Walser (12), the electrocardiograms of trained athletes showed initial increases in the height of the T waves after strenuous exercise, followed by prolonged flattening of the waves. Wolf (13) demonstrated that in relatively untrained subjects fatigue increased the amplitude of the P and S waves and decreased the amplitude of the T and R waves, whereas the electrocardiograms of some of the better trained subjects showed higher R, S, and T waves and lower P waves after exercise on a treadmill. The electrocardiograms of most of the subjects showed significant increases in the height of the P waves in leads II, IV, and V. Wolf's leads IV and V were not the same as leads V_4 and V_5. Plas (10) reported that modifications of the electrocardiographic record, especially the P-Q and Q-T intervals, appeared as a result of effort.

That the evidence regarding the effects of single bouts of vigorous physical activity on the electrocardiogram is contradictory is probably related to variations in the type, duration, and strenuousness of the exercises employed, differences in physical fitness of the subjects, time lapse between termination of exercise and recording of the electrocardiogram, and other similar factors. So far as the writers are aware, the only electrocardiographic study of participants in a boxing or wrestling tournament is that reported by Butterworth and Poindexter (3), in which they recorded before and after each bout the electrocardiograms of 35 competitors in a Golden Gloves Boxing Tournament. They observed that most of the tracings obtained after exercise showed an increase in the height of the P waves in leads II and III, with a tendency to sharpening and pointing of the waves, a definite decrease in the height of the T waves in the standard leads, and an increase in the height of the T waves in the precordial leads. These observations, they noted, were in partial disagreement with those of Barker, Schrader, and Ronzoni (1).

Procedure

A tournament was held in Hollywood, California, from April 28 to May 2, 1956, to select the members of the United States Free Style Olympic Wrestling Team. A number of the competitors agreed to serve as subjects and to present themselves for electrocardiograms before and after each competitive bout.

Pre-exercise electrocardiograms were to have been recorded 15 minutes before each bout to allow subjects sufficient time to warm up for the coming contest. In some instances, however, unexpectedly quick falls in preceding bouts made it necessary for the investigators to complete the pre-exercise tracings only shortly before a subject entered competition. In a few instances, the subjects won or lost in a quick fall; however, most of the bouts were won or lost on points and lasted the full time (12 minutes). Post-exercise electrocardiograms were not recorded until 15 minutes after conclusion of a bout because most subjects experienced severe muscular tremor, which, according to some investigators (7) parallels fatigue, and which interfered with recording immediately after competition. In each instance, a standard 12-lead electrocardiogram was obtained by means of a Burdick-type EK-2 direct-writing electrocardiograph while the subject lay supine on a plinth.

Results and Discussion

In a study such as this, it is almost inevitable that some of the subjects will be eliminated from competition. It had been hoped to obtain complete data on the winners, but this did not prove possible. Moreover, during this particular investigation, unanticipated changes occurred, with the result that some of the athletes were moved to another building located several blocks from the original site of the tournament and competition there was conducted at irregular intervals. Having only one electrocardiograph available, the investigators were compelled to move back and forth from building to building to record when possible, rather than adhering to the strict schedule which they had planned. All the electrocardiograms were measured in accordance with the directions given by Cureton and others (5).

Table 1 presents selected measurements from the electrocardiograms of a champion wrestler who qualified for the Olympic team and whose electrocardiographic series was almost complete. These data show that the amplitude of P_2 increased after competition, without exception, and that the ampliture of T_2 and T_{V5} invariably decreased. There was a marked tendency for R_2 to increase and for S_2 to decrease, although this was not available. The Q-T interval remained unchanged or decreased, whereas the P-R and QRS intervals showed no decided tendency one way or the other. No marked changes in the electrocardiographic measurements of this wrestler were observed in the tracings recorded before and after the series of seven bouts in four days.

Selected measurements from the electrocardiograms of another champion wrestler, who also qualified for the Olympic team, are presented in Table 2. It is apparent from a comparison of the pre-tournament, mid-tournament, and post-tournament electrocardiograms that with the exception of diminution of the Q-T intervals, changes in these selected measurements tended to be irregular; however, there were no marked differences between his pre-tournament electrocardiogram and that recorded after the final bout.

TABLE 1
Selected Electrocardiographic Measurements of Subject No. 1

Subject No. 1	Amplitudes (mv.)					Intervals Lead II (sec.)		
	P_2	R_2	S_2	T_2	T_{V5}	P-R	QRS	Q-T
First Day								
Pre-Bout	0.6	16.7	2.0	2.9	4.0	.180	.080	.439
Post-Bout	1.0	23.4	2.0	1.8	1.3	.168	.084	.356
Difference	0.4	06.7	0.0	−1.1	−2.7	.012	.004	−.080
Second Day								
Pre-Bout	0.5	11.1	0.8	3.4	5.4	.164	.080	.468
Post-Bout	1.7	19.6	1.5	1.6	4.0	.184	.096	.356
Difference	1.2	08.5	0.7	−1.8	−1.4	.020	.016	−.112
Third Day								
Pre-Bout	0.6	18.2	3.4	2.4	2.0	.148	.088	.432
Post-Bout	1.5	21.7	1.8	1.0	1.9	.160	.092	.360
Difference	0.9	03.5	−1.6	−1.4	−0.1	.012	.004	−.072
Fourth Day								
Pre-Bout	0.1	19.4	2.5	3.3	4.5	.136	.080	.436
Post-Bout	1.4	17.8	2.2	1.5	2.7	.160	.076	.360
Difference	1.3	−1.6	−0.3	−1.8	−1.8	.024	−.004	−.076
Pre-2nd Bout	0.3	18.5	2.3	2.9	4.6	.176	.080	.452
Post-2nd Bout	1.8	20.5	1.4	1.8	3.2	.160	.080	.356
Difference	1.5	02.0	−0.9	−1.1	−1.8	.016	.000	−.096
Pre-3rd Bout	0.1	17.8	2.5	2.5	3.9	.148	.080	.392
Post-3rd Bout	1.7	21.8	1.9	2.3	3.2	.176	.076	.392
Difference	1.6	03.0	−0.6	−0.2	−0.7	.028	−.004	.000

TABLE 2
Selected Electrocardiographic Measurements of Subject No. 2

Subject No. 2	Amplitudes (mv.)					Intervals Lead II (sec.)		
	P_2	R_2	S_2	T_2	T_{V5}	P-R	QRS	Q-T
First Day								
Pre-Bout	1.4	8.5	2.3	3.3	5.7	.208	.080	.492
Third Day								
Pre-Bout	1.6	8.9	1.8	3.0	4.1	.176	.068	.392
Post-Bout	1.6	8.0	2.4	2.8	3.6	.068	.068	.360
Difference	0.0	−0.9	0.6	−0.2	−0.5	−.108	.000	−.032
Fourth Day								
Pre-3rd Bout	1.3	7.9	1.9	3.8	9.2	.176	.080	.428
Post-3rd Bout	1.9	8.5	1.8	3.8	4.7	.176	.084	.388
Difference	0.6	0.6	−0.1	0.0	−1.5	.000	−.004	−.040

Measurements from the records of two wrestlers whose electrocardiograms were obtained before the tournament started and following the last bout in the semi-final rounds are presented in Table 3. These are typical of most of the other records in that they show no marked changes in the electrocardiographic measurements recorded before and after three consecutive days of competitive wrestling.

TABLE 3

Selected Electrocardiographic Measurements of Subjects No. 3 and No. 4

Subjects Nos. 3 and 4	Amplitudes (mv.)					Intervals Lead II (sec.)		
	P_2	R_2	S_2	T_2	T_{V5}	P-R	QRS	Q-T
Subject No. 3								
Pre-Bout	0.1	15.3	1.0	2.5	2.3	.136	.080	.380
Post-Bout 3rd Day	0.5	13.9	1.5	2.6	2.5	.160	.076	.380
Difference	0.4	−01.4	0.5	0.1	0.2	.024	−.004	.000
Subject No. 4								
Pre-Bout	1.0	13.5	—	2.9	4.3	.140	.080	.394
Post-Bout 3rd Day	1.8	15.0	—	2.8	3.3	.160	.076	.348
Difference	0.8	01.5	—	−0.1	−1.0	.020	−.040	−.036

TABLE 4

Selected Electrocardiographic Measurements of Subject No. 5

Subject No. 5	Amplitudes (mv.)					Intervals Lead II (sec.)		
	P_2	R_2	S_2	T_2	T_{V5}	P-R	QRS	Q-T
First Day								
Pre-Bout	0.8	13.0	3.0	1.5	2.2	.108	.128	.35(
Post-Bout	0.6	11.7	3.0	0.0	0.8	.092	.120	.260
Difference	−0.2	−1.3	0.0	−1.5	−1.4	−.016	−.004	.096
Second Day								
Pre-Bout	1.4	16.0	3.3	1.0	0.9	.120	.112	.372
Post-Bout	1.2	17.2	3.7	0.25	2.0	.108	.124	.352
Difference	−0.2	01.2	0.4	−0.75	1.1	−.012	−.012	−.020
Third Day								
Pre-1st Bout	1.4	15.3	3.4	2.0	2.2	.120	.132	.388
Post-1st Bout	1.9	16.7	3.7	0.25	1.4	.108	.104	.240
Difference	0.5	01.4	0.3	−1.75	−0.8	−.012	−.028	−.148
Pre-2nd Bout	1.7	10.0	3.6	1.8	1.8	.120	.112	.360
Post-2nd Bout	2.1	11.8	2.9	1.2	0.25	.104	.120	.344
Difference	0.4	01.8	−1.0	−0.6	−1.55	−.016	.008	−.016

Selected measurements from the electrocardiograms of a wrestler who was eliminated in the semi-final round are presented in Table 4. His pre-competition record revealed a Wolff-Parkinson-White syndrome. According to some cardiologists, this relatively benign sign occurs when one ventricle is activated early by the bundle of Kent, which by-passes the auriculoventricular node and is observed primarily in males with no evidence of heart disease (8). The electrocardiograms of this wrestler failed to show any marked changes as the tournament progressed and, in general, those that were observed were consistent with the changes observed in wrestlers having normal electrocardiograms. It is of interest that this wrestler was in a state of extreme fatigue following the bout in which he was eliminated. The investigators observed no other wrestler during the entire tournament in comparable physical distress following a bout.

In a sixth subject, eliminated in the quarter-finals, the electrocardiogram recorded after the first bout showed slight depression of the ST segment in lears I, II, III, and AVR, suggesting subendocardial injury, inversion of the T wave in AVF, and low T waves in lead II. There were no essential changes in the V leads, although the T waves were somewhat low. These changes were in striking contrast to those observed in the tracings of the other subjects.

Conclusions

The findings of this study support the following conclusions:

1. Four subjects having normal resting electrocardiograms showed no marked electrocardiographic changes following participation in a competitive wrestling tournament lasting four consecutive days.

2. A comparative analysis of the pre-exercise electrocardiograms and the post-exercise electrocardiograms of these four subjects revealed the following changes as a result of competitive wrestling: An increase in the amplitude of P_2 with one exception; a decrease in the amplitude of T_2 and T_{v5} with few exceptions; and diminution of the Q-T interval, with the exception of two electrocardiograms which remained unchanged in this respect. Post-exercise electrocardiograms failed to show consistent changes in the measurements of R_2, S_2, the P-R interval, and duration of the QRS complex.

3. A single subject, whose pre-competition electrocardiogram presented the Wolff-Parkinson-White syndrome, showed electrocardiographic changes as a result of competition which were consistent with those observed in the post-exercise records of wrestlers whose tracings were normal.

4. A single subject, whose electrocardiogram was normal before competitive wrestling, showed electrocardiographic changes suggesting subendocardial injury following competition.

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Relationships of Body Fat to Motor Fitness Test Scores[1]

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Abstract

The purpose of this study was to examine the relationships between per cent body fat and selected motor fitness tests. Significant negative correlations of from —0.29 to —0.68 were found between per cent body fat and the selected motor fitness tests. The test items most affected by fat were those which involved running and jumping. Weight did not significantly affect the performance of any of the test items except the 220-yard dash.

BODY FAT generally has been considered to be a liability in the performance of motor activities. However, very few objective studies have been done showing the direct relationship between body fat and the performance of various motor activities. Direct evidence of this nature would be very useful in demonstrating, to both athletes and non-athletes, the effects of excess fat on their capacity for motor activity.

Kireilis and Cureton (5) have reviewed the literature and studied this problem. Their study and one by Grover (3), which they cite, report the deleterious effects of excess body fat on motor performance. However, these data are based on an estimation of fat from skinfold thickness measurements, a method that could yield considerable error owing to lack of standardization in measurement methods and instruments.

Purpose of the Study

The purpose of this study was to determine the effects of body fat on motor fitness test scores using hydrostatic weighing methods to determine body density and thus body fat.

Procedure

A total of 61 young men on active duty with the Armed Forces were randomly selected to serve as test subjects in this experiment. The men had

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recently completed basic training and were awaiting assignment. The mean, standard deviation, and range for age, height, weight, and per cent body fat are shown in Table 1.

TABLE 1
Characteristics of Test Subjects

Characteristic	Mean	S. D.	Range
Age (yrs)	19.8	± 2.51	17-31
Height (cm)	175.7	± 6.90	158-191
Weight (kg)	69.8	±10.50	52-100
Body fat (%)	13.0	± 4.26	5.6-26.8

Body fat was computed from body density by the equation of Keys and Brozek (4). Body density was determined by the Archimedian Principle, using the specific gravity technique described by Pascale, *et al.* (6). The residual lung volume was computed by the oxygen flushout technique of Cournand, *et al.* (2). The nitrogen content of the expired gas was analyzed by the method of the Van Slyke & Sendroy (8).

The motor fitness test items selected to compose the test battery are representative of those usually employed. Motor fitness tests are designed to test the fundamental or gross big muscle movements that are basic to athletic or work skills. The entire battery of tests was administered during one testing period. At least 15 minutes were allowed between each test. During the testing period, the subjects were dressed in fatigue coveralls and "gym shoes." The entire battery of tests was administered three times with at least one day between trials.

The average of three measurements was used in all calculations involving push-ups, sit-ups, and squat thrusts. These tests were administered as outlined in the U. S. Army Physical Training Manual FM 21-20 (7) for the U. S. Army Physical Fitness Test. Push-ups were counted until the subject could no longer continue. Sit-ups were counted for two minutes with the scorer holding the performers' ankles firmly against the floor. Squat thrusts were scored as the number completed in 60 seconds.

The lowest time was used for calculations involving the 75-yard dash and the 220-yard dash. In scoring the three standing broad jumps, the longest distance was used. The 75- and 220-yard dashes were run on a hard dirt surface. The normal track starting position was used. Coaching and practice in the correct method of starting were given to all subjects who were unfamiliar with the proper technique. The average time from two stop watches was recorded. The three standing broad jumps were made on a grass surface. Distance jumped was recorded to the nearest inch.

Analysis of the Data

The results of this study appear in Table 2. These correlations clearly show that fat is a limiting factor in the performance of the motor performance test

TABLE 2
Correlations of Motor Performance Tests with Per Cent Body Fat and Body Weight (N = 61)

Motor Performance Test	Correlations with Per Cent Body Fat		Correlations with Body Weight	
	r	p	r	p
Push-ups	—0.37	0.005	—0.15	n.s.
Squat thrusts	—0.24	0.100	—0.21	n.s.
Sit-ups	—0.29	0.025	—0.09	n.s.
Three standing broad jumps	—0.61	0.001	—0.13	n.s.
75-yard dash	—0.52	0.001	—0.22	0.10
220-yard dash	—0.68	0.001	—0.38	0.005

items included in this study. The skills that were most affected by fat were those that involved horizontal movement of the body, i. e., three standing broad jumps, 75-yard dash, and the 220-yard dash. That this effect was caused by the fat and was not merely a reflection of body weight can be shown by the data in Table 2, which shows the correlations between motor skills and body weight.

The correlations between motor skills and body weight show that all but one of the motor fitness test items included in this study were not significantly affected by weight. The one item that was significantly affected by weight was the 220-yard dash. Application of the predictive index (1) shows that the 220-yard dash was affected 3.5 times more by fat than it was by body weight.

To further define the effects of fat on motor performance, the scores of the various tests were grouped according to per cent body fat. These groups are less than 10, 10-15, and greater than 15 per cent body fat, with respective means of 8.28, 12.21, and 18.58. The results of this treatment appear in Table 3. The data from the 220-yard dash, 75-yard dash, and three standing broad jumps clearly show that the mean scores of the groups become poorer as the per cent of body fat increases. An arithmetical decrease in performance capacity existed in squat thrusts, sit-ups, and push-ups. The only statistically

TABLE 3
Comparison of Mean Test Scores Classified According to Per Cent Body Fat

Test	Group L <10% Fat (N = 15)		Group M 10-15% Fat (N = 30)		Group H >15% Fat (N = 16)		Level of Significance P		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	L-M	M-H	L-H
220-yard dash	29.3	3.29	31.6	2.55	35.0	3.62	0.025	0.001	0.001
75-yard dash	9.8	.66	10.1	.64	10.7	.73	n.s.	0.01	0.001
Three standing broad jumps	23.8	1.98	22.7	1.18	20.2	2.10	0.025	0.001	0.001
Squat thrusts	27.2	3.23	28.8	4.46	25.2	3.65	n.s.	0.01	n.s.
Sit-ups	43.4	11.12	41.6	10.11	36.2	11.90	n.s.	n.s.	n.s.
Push-ups	30.9	7.20	29.1	11.66	25.9	13.60	n.s.	n.s.	n.s.

significant difference in these latter items existed in squat thrusts between the 10-15 per cent group and the greater than 15 per cent group.

The results of this study substantiate the similar studies by Kireilis and Cureton (5) and Grover (3). Although the test items described in this report are not identical with the test items previously studied, the correlations for similar items are considerably higher. It would appear that the more exact estimation of fat from hydrostatic weighing has brought out the negative effects of fat more clearly than estimations of fat from skinfolds.

Conclusions

1. Significant negative correlations of from —0.29 to —0.68 were obtained between performance in the selected motor fitness test items and per cent body fat.
2. The motor fitness test items most affected by fat were those which involve running and jumping.
3. Weight did not significantly affect the performance of any of the test items except the 220-yard dash.

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(Submitted 11/18/57)

Isometric Fatigue Curves in Human Muscle with Normal and Occluded Circulation[1]

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Abstract

Fatigue curves for the forearm muscles during sustained isometric contraction were obtained on 24 young men. No difference was found between the curves obtained with and without artificial occlusion of the circulation, down to the point where the exerted force became less than approximately 60 per cent of the maximal strength. Below this critical level, the exerted force continued to diminish under the occluded condition, but leveled off when there was no occlusion. The leveling off was explained as due to the systolic blood pressure being higher than the prevailing intra-muscular pressure at this stage of fatigue. A mathematical equation, the components of which were derived from broad physiological considerations of the factors involved, fitted the observed data accurately.

RECENTLY a systematic attack on the phenomena of strength gained through physical training was started by Hettinger and Müller (6), who conducted a series of 71 tests dealing with work load, frequency of work-out, dynamic and static training. One of the interesting points in their discussion of results was the suggestion that the gain in strength was dependent on the degree of oxygen deficit in a muscle fiber during its contraction. They found that a work load which caused the muscle to exert less than approximately a third of its maximal force produced no training effect, presumably because this work load was insufficient to produce the oxygen deficit. Hettinger (5) investigated the effect of dynamic (isotonic) versus static (isometric) contractions at a work load of a fifth of the maximal force, i.e. well under the training load which according to their earlier study should result in a substantial oxygen deficit. His data showed that neither type of training had any effect at this load.

In both studies, static contractions were considered to be the most effective type for causing increase in strength. Because only one isometric contraction per day (of 6 seconds duration at ⅓ maximal) was needed to increase maximal strength at a rate of 5 per cent per week, static exercise was thought to offer the most effective and least time consuming method of strength training.

The oxygen deficit factor is the only physiological explanation offered by these writers for the increase in strength. Oxygen deficit causes an imbalance

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of the depletion-replenishment mechanism. The deficit would be minimal, if the circulation through the working muscle were unimpaired. Apparently, very little is known about the extent to which impairment in the local circulation is due to the muscle contraction itself, except for the general belief that the circulation is occluded in a maximally contracted muscle (1,2). Maximal isometric contraction, however, brings about fatigue, which in turn diminishes the amount of tension produced. Consequently, the tension will decrease to a point where it no longer impairs the circulation.

Although fatigue curves for intact human muscle have been described for serial dynamic contractions (3), no analysis of the fatigue curve for static contractions was found. An investigation of such a curve, and a comparison with the serial contraction fatigue process, should be of considerable interest. Such a study would certainly require consideration of the differential effects of internal muscle tension on the muscle circulation.

Apparatus and Method

The instrument used was a spring-loaded Smedley hand dynamometer which was attached with a flexible wire to a recording ergograph, as used by Grose (3). The first test consisted of a static contraction which was kept at maximum effort for 90 seconds. A second test was given in the same manner, but with the circulation occluded by a pressure cuff around the upper arm, inflated to 220 mm. Hg. The cuff was inflated between the first and fifth second of the contraction and was kept under pressure until 90 sec. had elapsed.

Twenty-four male students enrolled in physical education activity classes were used as subjects. Since they were tested twice under each of the two conditions, they were divided into two groups and the four tests were administered on a rotating basis so as to balance any training factor. The tests were separated by an interval of one week. The subjects were instructed not to engage in any vigorous activities on the day of the test.

Results

Figure I shows the mean values for the 24 subjects for each condition, measured at 5-second intervals. The smooth curves are plotted from the theoretical equations that will be explained later. It can be seen in this figure that the difference between the results under the two conditions was negligible at the start of the fatigue curves.

No appreciable drop in exerted force occurred for either performance until the 15-second mark where the strength began to fall at an increasing rate for both conditions. After approximately 50 sec., however, a difference between the two types of performance began to appear: the occluded curve continued its downward trend, while the non-occluded curve did so to a lesser extent. At the termination of the test (90 sec.) the difference between the two curves was highly significant ($t = 8.2$).

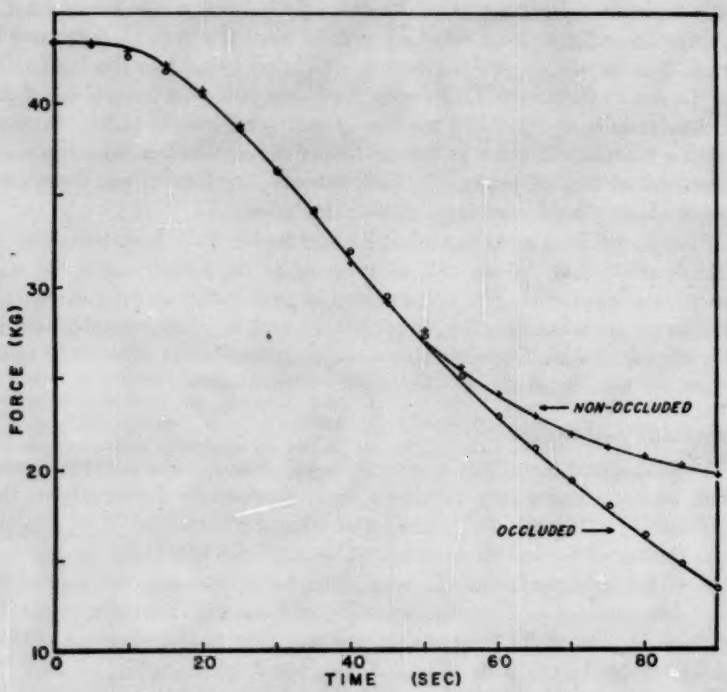

FIGURE I. Isometric Fatigue Curves for Forearm Muscles.

The fact that no difference appeared before 50 sec. may be taken as indirect evidence that the circulation was effectively occluded by internal muscle pressure up to this time. When the force diminished to a value less than approximately 60 per cent of the initial strength, circulation began to occur through the muscle in an amount sufficient to reduce greatly the downward trend in the curve for the non-pressurized condition. In contrast, the curve under the pressurized (artificially occluded) condition continued its downward trend.

THEORETICAL CONSIDERATIONS

In deriving a mathematical equation to describe the shape of the occluded and non-occluded curves in Figure I, it is necessary to give consideration to the physiological processes involved, at least in their broad connotations.

Firstly, there should be a component that is concerned with the depletion of the immediately available energy reserves. These may be high-energy phosphate compounds such as adenosine triphosphate and phosphocreatine. The influence of this factor on the muscle in maintained maximal tension is visualized as being important only during the first 5 or 10 seconds. Decrease

of this reserve can be described crudely by an exponential term $a_1e^{-k_1t}$, where e is the Naperian log base (2.718), k is a rate constant, a is proportional to the initial amount of the reserve, and t is the time elapsed since the beginning of the contraction. Depletion should be very rapid, since there has been no time for any restorative mechanisms to come into play to a significant amount.

Secondly, the major factor that describes the tension curves, especially that for occluded circulation, would be one that represents the theoretically available energy from glycogen breakdown. (The biochemical mechanism will of course involve the formation of high-energy phosphates, primarily in the Krebs cycle). As this energy store is depleted and metabolites are formed, it declines in its net contribution to muscular tension. Amount of depletion during any particular time period of the contraction is visualized as being proportional to the amount of the store available at the beginning of that particular time period. This leads to the exponential expression $a_2e^{-k_2t}$.

Thirdly, since the conversion of glycogen to energy in a form that is available to the muscle is initiated by the muscle contraction itself, there should be a dynamic time lag in the process: stored glucose or glycogen to energy. The amount of time lag is visualized as decreasing by a constant proportion per unit of elapsed time, and thus can be represented by a *negative* exponential term $-a_3e^{-k_3t}$.

Fourthly, it may be visualized that the pressure within the muscle (produced by the contraction) is sufficient to occlude the blood flow during the contraction under normal conditions. This condition occurs until fatigue has decreased the muscle tension to the point where the systolic blood pressure is greater than the pressure within the muscle. Beyond this point, arterial blood flows through the muscle to an increasing extent as the muscle tension diminishes. This arterial blood can produce oxidative restoration of the energy-producing mechanisms. It is an increasing function, which approaches an asymptote because there is a finite limit to the possible amount of blood flow. The effect can be represented by the exponential term $a_4(1-e^{-k_4t^1})$ where t^1 is measured from the point of time where the internal muscle pressure and the blood pressure just balance each other. This factor adds to the three exponential terms described earlier. However, when the blood flow is occluded, as by the use of an inflated blood pressure cuff, it cannot come into operation, and the tension curve continues to decline exponentially as described by the term $a_2e^{-k_2t}$.

The complete mathematical form which expresses the muscle tension y at any time t will therefore be given by the equation:

$$y_t = a_1e^{-k_1t} + a_2e^{-k_2t} - a_3e^{-k_3t} + a_4(1-e^{-k_4t^1})$$

Curve Fitting

The method used for fitting the mathematical curve to the observed data (i.e., determining the parameters a and k) was essentially that used by

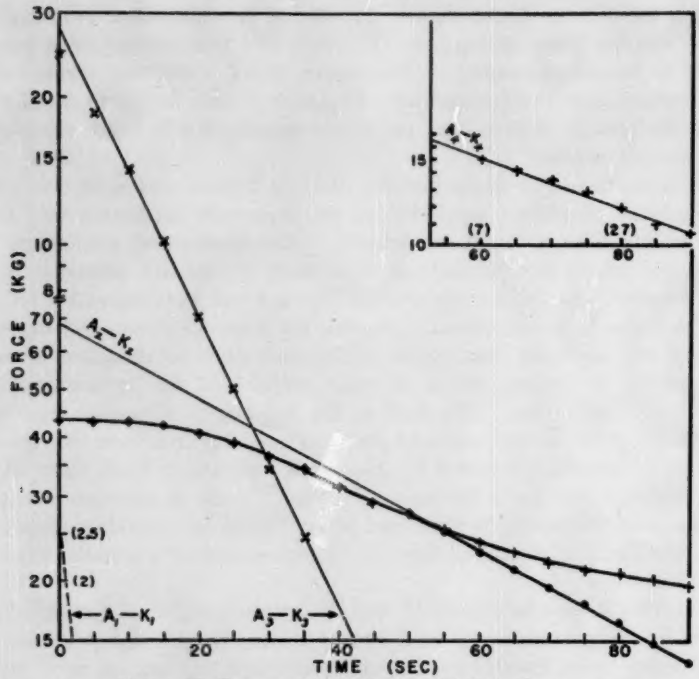

FIGURE II. Exponential Analysis of Fatigue Curves.

Henry (4). The first step was to plot the data for the circulation-occluded condition on a semi-log graph (Figure II), and to fit a straight line by inspection to the last half of the points, which appeared to follow a linear trend. (An exponential curve yields a straight line when plotted on a semi-log graph).

This straight line was extended to the left until it passed through the zero time axis, where the intercept value was read off as $a_2 = 68.4$ at zero time. The amount of time required for the linear curve to drop to its half-way point was read from the graph as 38.2 sec., and k_2 was computed by the usual half-time procedure as .693/half-time = .01815. It should be noticed that the term $a_2e^{-k_2t}$ has only the two parameters a and k (since e is a constant, and t is the independent variable). The numerical values of these two parameters, however, have been determined by nine points on the graph.

The second step was to subtract the plotted data on the left half of the graph from the extended straight line representing $a_2e^{-k_2t}$. These differences were plotted in their correct time position, using the symbol x. It may be seen in Figure II that if the first point (at zero seconds) is disregarded for the present, the remaining seven points define a straight line (two parameters) with zero intercept at $a_3 = 27.6$, and a half-time of 10.04 sec., corresponding to $k_3 = .0690$.

The third step was to subtract the computed value of $a_2e^{-k_2t} - a_3e^{-k_3t}$ from the observed data at zero and five sec. This left the residuals $a_1 = 2.46$ at zero sec. and 0.33 at 5 sec. (The discrepancy at the next point (10 sec.) was negative and could not be plotted on the semi-log graph). These two residuals were also plotted on the graph, and used to determine the zero intercept as $a_1 = 2.46$ and the half-time as 1.72 sec., which corresponds to $k_1 = 0.404$. Since there were only two points to define two parameters, it cannot be claimed that the $a_1 - k_1$ term has been established as exponential. On the other hand, its exact mathematical form is of little concern in the present problem; it is sufficient that we can account for some small and very rapidly depleting energy reservoir in a general way by the term $a_1e^{-k_1t}$. This component exerts its influence for only the first few seconds of the fatigue curve.

The above three-component equation describes the circulation-occluded data very accurately as shown by the smooth curves in Figures I and II, which were obtained by computation from the formula. The standard deviation of the distribution of errors is only 0.32 kg.

For the non-occluded condition, the fourth component was obtained by subtracting the above three-component curve from the obtained data for that condition (shown by the symbol + in Figure II). The residuals did not depart appreciably from zero until after 50 sec. From that point onward, they increased systematically. Their successive values at 5 sec. intervals, beginning at 60, were 1.8, 2.6, 3.4, 4.4, 5.5, 6.6, and 7.3 kg. The value of their asymptote, estimated from the extrapolated trend of the main curves of Figure II, seemed to be about 16.4 kg. This series of values can be plotted as an ascending exponential curve, which is nearly linear at the beginning, but bends over to approach gradually the limiting value 16.4 kg. The origin of this curve is at $t_0{}^1 = 53$ sec., and its mathematical form is represented by the expression a_4 $(1—e^{-k_4t^1})$, which may also be written $a_4—a_4e^{-k_4t^1}$. The first parameter, a_4, is the asymote 16.4 kg., thus the value of the term $a_4e^{-k_4t^1}$ at $t^1 = 0$ is also 16.4 kg. The successive values of the residuals given above, *subtracted* from the asympote, give a series of experimental points that are plotted in the insert graph of Figure II. A straight line fitted to these seven points has a half-time of 84 sec., therefore, k_4 is .693/84.0, which is equal to .00825. The time figures given in parentheses in the insert graph represent t^1, which is, of course, the time elapsed after the origin of the component at 53 sec.

The computed four-component curve describes accurately the data obtained under the non-occluded condition, as may be seen by the smooth curves in Figures I and II. The standard deviation of the distribution of errors is only 0.21 kg. The curve parameters for both conditions are summarized in Table 1.

TABLE 1
Exponential Curve Parameters

Parameter	Component			
	First	Second	Third	Fourth
a (force in kg.)	2.46	68.4	27.6	16.4
k (rate constant in sec^{-1}.)	0.404	0.01815	0.0690	0.00825
Half-time (sec.)	1.71	38.18	10.04	84.00

Discussion

Alternative Explanation. The possibility that pressure has blocked the flow of nerve impulses and is therefore responsible for the difference between the two curves appears unlikely. They are identical for the first half of the contraction, and fatigue in the last half under the occluded condition is simply a continuation of the downward trend established by the first half under normal conditions.

Relation to Serial Contraction Curves. At first glance the fatigue curve for an isometric contraction as obtained in the present study seems to be quite differently shaped than the single-term serial contraction curve as obtained by Grose (3). However, the apparently steep drop of his data would be less noticeable if the curves were plotted on the same time scale as used in Figures I and II. Another consideration is that he has based his mathematical curve on points obtained at intervals of 15 contractions. Since his exercise was performed at a rate of 30 contractions per minute, the time lapse between the first and second point on his curve is 30 seconds, as compared to 5 seconds in the present study. It could well have been that his data would have shown the same mathematical factors ($a_1 - k_1$ and $a_3 - k_3$) as the present study, had they been plotted in greater detail. In substantiation of this idea, it may be noticed that the third plotted point on his control curve (at 60 sec.) is somewhat higher than the curve he drew. This is also true of his curve for the massage condition. A better curve fitting would have placed his zero-time intercept at a somewhat higher value than the obtained first point, thus requiring the inclusion of the other components in order to fit the data closely.

The rest of his curve is comparable to the one obtained in the present study, being primarily under control of the factor a_2—k_2. The k_2 in the present study corresponds to a half-time of about 40 sec., while the k_2 of the Grose study corresponds to a half-time approximately twice as long. This difference could be explained in terms of the continuing partial recovery due to the recurring circulation between contractions in Grose's data, as compared to the steady occlusion of the circulation in the present study.

Comparison with the Hettinger-Müller Concepts. One of the interesting conclusions reached in their study (6) is that the training load should be at least a third of the maximal force, in order to bring about oxygen deficit

in the muscle fiber and thereby cause a training effect. A glance at the present data (Figure I) will show that one-third of maximal force is approximately at the region of the fatigue level asymptote, where the depletion and replenishment mechanisms balance each other when the circulation is unimpaired. Any isometric contraction above this asymptote is bound to evoke some deficit in the replenishment mechanism. The present study, therefore, seems to lend support to the Hettinger-Müller interpretation.

In one of Müller's experiments (7), both arms were trained isometrically but at different muscle tensions (⅓ and 2/3 of the maximal force). The rate of increase in strength from training was the same for both arms, which led to the conclusion that strength cannot be caused to develop at any faster rate, when the load is increased beyond a certain critical level. He tentatively set this level at 40 per cent. The results of the present study, however, suggest that he has placed the critical tension level too low. The region where the muscle pressure and the blood pressure are inferred to balance each other is 60 per cent of maximal force, thus loadings greater than this figure would be necessary to produce the maximum training effect.

Summary and Conclusions

The fatigue curve for intact human muscle under isometric contraction was studied with the use of a spring-loaded recording hand-dynamometer. Twenty-four young men were tested four times in a balanced series, twice while the blood flow to the forearm was occluded with a pressure cuff around the upper arm, and twice without occlusion. The initial strength averaged 43.3 kg.

No difference was found between the shape of the fatigue curves under the two conditions during the first fifty seconds of the isometric contraction, where the tension had not yet dropped as low as 26 kg. From this factual observation, it may be concluded that virtually no circulation can have occurred in the contracted muscle up to this time. Thus, a tension of 26 kg. is visualized as defining the point where internal muscle pressure and blood pressure just balance each other (at 60 per cent of maximal force). Below this critical level, circulation does flow through the non-occluded muscle, since there is relatively little fatigue beyond this point. In contrast, the occluded muscle continues to fatigue.

The fatigue curves could be fitted accurately by a mathematical equation consisting of the sum of several exponential components. These components were derived from broad physiological considerations of the factors involved. Three components described the curve for the circulation-occluded condition, and the fundamental part of the curve obtained under normal conditions. A fourth component (originating at the point where the muscle has fatigued to 60 per cent of maximal force) accounted for the reduced fatigue after 50 sec. of contraction when there was no artificial occlusion of the blood flow.

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Action Potentials in Unexercised Arm When Opposite Arm Is Exercised[1]

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Abstract

The electrical activity in an unexercised arm was recorded when the opposite arm was exercised. The subject exercised the opposite arm by raising it to a 45° angle, as four and one-half pound weights were systematically added until the subject could no longer perform the exercise. The microvoltage was recorded by taking a photograph of the cathode-ray-oscillograph.

It was found that: (a) the microvoltage increased as the resistance increased; (b) on an average, 70% of maximum strength elicited a potential of ten microvolts in the unexercised arm; and (c) maximum contractions elicited, on an average, 30.4 microvolts in the unexercised arm. It is concluded that either muscle setting or active exercises will elicit higher potentials in an arm than will exercising the opposite arm against maximum resistance.

IN THE MAJORITY of studies relative to the bilateral effects of exercise, the improvement of muscle strength in an unexercised arm has been used as the criterion. The factor, or factors, that bring about such an increase have not been reported.

When a body part is immobilized, the muscles involved become atrophied. In order to prevent atrophy, the involved muscles must be stimulated. The stimulation, regardless of type, will cause a wave of excitation in the muscle—commonly called a contraction. This contraction is generally described as an electro-chemical phenomenon. The microvoltage produced during a contraction is measurable by means of an electromyograph. Whether or not the maintenance or development of muscle strength in an unexercised arm may be attributed to its contraction when the muscle in the opposite arm is being exercised has not been clearly established. It is the purpose of this study, therefore, to determine whether or not there is electrical activity in an unexercised arm when the opposite arm is being exercised.

The studies of "cross education" or bilateral effects of exercise developed considerable interest in this country about 1900. In an early study conducted in the Yale psychological laboratory, it was found that the exercise of one hand with a dynamometer resulted in an improved muscular performance of the other hand. In a second study (11) conducted in the same laboratory, a systematic exercise (with dumbbells, a dynamometer, and an ergograph) of one part of the body brought about a great improvement in resistance to

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fatigue, and an increase in the size of the muscles on the "unpracticed side." Note was also made of the fact that exercise effects were greatest in the related parts of the opposite side. For the exercise effects in the unexercised member, Wissler and Richardson concluded: ". . . it must not be claimed that muscles do not receive cross-exercise until more refined methods of observation are used that heretofore were unavailable in such experiments."

Hellebrandt (7, *p. 76*) suggested that "cross education" was more correctly stated by the title of her study, "The Influence of Unilateral Exercise on the Contralateral Limb," and drew several conclusions, including the following:

Unilateral heavy resistance exercise which rapidly augments the strength and staying power of the ipsilateral limb has a strikingly similar concomitant effect on the contralateral unpracticed limb.

The determining casual factor in so-called cross-education is the severity of the effort evoking the response rather than the duration of the exercise.

It is suggested that cross education has a dual genesis in the diffusion of motor impulses to the unpracticed side via irradiation and tonic postural reflexes arising in and acting on the limbs but modulated by reflex mechanisms situated in the brain stem.

Cross education is a misnomer if it presupposes that the unpracticed limb is unexercised.

Dodge and Bott (6) wrote that there is "a more or less widespread wave of motor excitation in the voluntary flexion and extension of a mobile member. Just how widespread it is we do not know."

Davis (4) stated the following:

Even in a very simple sort of response there is a widespread "structural" pattern of action. The true unit of activity must be not the flexing or extending of a particular muscle or limb but an adjustmental design in which many regions of the organism participate.

Slater-Hammel (10, *p. 208*) suggested that, "further insight into the nature, extent, patterns, and conditions of remote muscular excitation will lead to a better understanding of physical education activities and corrective procedures." The use of the transfer effects of exercise as a therapeutic tool has been suggested by Hellebrandt, Parrish, and Houtz (7, *p. 85*).

The majority of authors agree that exercise of one arm improves the muscular performance in the other. Slater-Hammel's findings (10, *p. 209*) indicate that exercise of one arm produces a positive and significant improvement in the muscular performance of the other arm. Laun (8) summarized his study by stating that "It has been proven by this study that in exercise of the forearm flexors and extensors of one arm there is a carry-over strength to the opposite arm." Davis (4, *p. 350*) stated: "There could be no doubt that there is considerable activity in the right leg during voluntary movement of the left foot." It was found upon measurement, however, that in some subjects the action potentials for an unexercised limb may show a lower value for the response period than for the pre-response period.

Slater-Hammel (10, *p. 203-208*) summarized previous studies by saying:

These studies indicate that simple voluntary movement in one limb is accompanied by muscular activity in all four limbs. In an extension of the right foot, with the subject reclining, there is not only the normal muscle activity in the extensor muscles of that member, but there is also muscle activity in the extensor muscles of the left

foot and the two hands. While this remote activity is much less than that of the active member, it is, nevertheless, substantial.

In view of the general results obtained in transfer studies, it would seem that this remote activity is great enough to constitute a form of muscular exercise.

The evidence obtained shows that a systematic exercise program involving the flexion and extension of one arm results in a positive and significant improvement in the other arm. While these results are in general agreement with earlier studies, they must be interpreted with some caution. It is, of course, possible that the bilateral effects were due simply to a raising of the subjects tolerance to fatigue sensation. During strenuous and systematic exercise of one group of muscles a person probably learns to ignore or tolerate the feelings of muscular fatigue for a greater period of time, and this may transfer and influence the performance of other muscle groups. Also, it is possible that the training effect is due to a bilateral transfer of coordination. On the other hand, the fact that bilateral gains are rapidly lost after the cessation of exercise suggests the gains are due primarily to exercise.

Electromyographic studies present numerous problems, among which are both the type and the placement of electrodes. In an effort to determine the advantages of different types of electrodes, Denslow and Hassett (5, *p. 652*) experimented with three types. The three types were the concentric surface electrode, the bare hypodermic needle, and the hypodermic needle covered (to within two millimeters of the tip) with enamel. They found that the surface electrode was highly selective for use on superficial muscles. They indicated that the hypodermic needle probably picked up energy from several motor units and apparently permitted some loss in voltage by either leakage or cancellation or both. They concluded that the covered hypodermic needle seemed to be a compromise between the other types. Important objections advanced against the use of the hypodermic needle were the possibility of inducing nausea in subjects and difficulty of maintaining the needles in a sterile condition. According to Brazier, Watkins, and Michelsen (3), the data secured by means of surface electrodes are essentially the same as those derived from needle electrodes.

Bierman and Yamshon (1, *p. 207*), in their study, used surface electrodes for several reasons. First they studied only those muscles which were superficial. Surface electrodes were found to be satisfactory, and their application did not cause pain. The experimenters considered "it objectionable to have a needle inserted into the belly of the muscle which was actively contracting."

Denslow and Hassett (5, *p. 653*) practically disregarded the problem of electrode placement: "The area from which a motor unit can be recorded varies from two to seven centimeters vertically and from one to six centimeters horizontally." However, Lindsley (9), holding a contrary opinion reported: "The movement of the electrodes a millimeter one way or the other often completely eliminates the response of a unit."

As a general guide for the placement of electrodes, Bierman and Yamshon (1, *p. 207*) have suggested.

First determine the motor point by electrical stimulation of the muscle under observation and then (to) place each of the electrodes at an approximately equal distance away from this point, so that a line drawn between the two electrodes would be parallel

to the muscle fibers. We found the usual minimum distance between the two electrodes to be approximately 2.5 centimeters.

Borchardt concluded:

. . . With but few exceptions, as the distance of the electrodes from the motor point increased, whether this distance was proximal, distal or straddled, the amplitude recordings also increased.

. . . The weakest amplitude recordings were obtained when the electrodes were placed on or near the motor point, whether proximal, distal or straddled.

. . . It appeared that as more muscle fibers of the rectus femoris were included between electrodes, the greater were the amplitude recordings.

. . . The amplitude recordings from the rectus femoris muscle were increasingly higher as the distance between the electrodes increased equidistantly from the motor point.

Procedure

The subjects used in this study were 17 male graduate students at the State University of Iowa. The subjects were instructed concerning the general procedure but were not told the nature of the experiment.

For the purpose of uniformity, the motor points on each muscle were selected as the attachment area for the electrode plate (Figure I). This plan was continued throughout the study. In a preliminary experiment, the distance from the electrode plate to the surface electrode was determined on

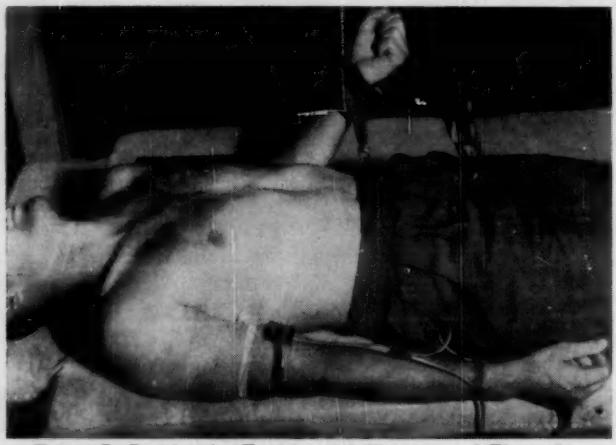

FIGURE I. Position for Exercise and Placement of Electrodes.

several subjects to make certain the voltage of the contracting muscle would be sufficient to supply an adequate record. The same spacing of the surface electrodes was used for all the subjects.

The following preparations were made before each subject was tested:

1. The subject assumed a supine position as shown in Figure I.
2. Electrode paste was spread on the electrode plate, the ground plate, and the surface electrodes.

3. The electrode plate was fastened over the motor point of the long head of the biceps brachii (Figure I) that was not exercised.

4. The ground plate was then fastened approximately one foot distal to the electrode plate on the forearm.

5. The first surface electrode was placed on the biceps brachii two centimeters proximal to the motor point.

6. Another surface electrode was placed two centimeters proximal to the distal motor point of the rectus femoris of the nonexercised side of the body. The purpose of this placement was to determine if there was activity in other remote muscles.

7. The electromyograph, which was a Meditron model 201-A, was adjusted as follows:

A. Sensitivity	100
B. Volume	5
C. Sweep time	30
D. Focus	5
E. Intensity	8
F. Vertical amplitude	5

The following procedure was established for the exercise performed by each subject:

1. The electrode on the biceps brachii was connected to the electromyograph and the subject was asked to lift a 4.5 pound weight until his forearm was at a 45° angle with his arm as shown in Figure I. This position was maintained by the subject until a photograph of the scope had been taken.

2. Four and one-half pounds were added each time the subject performed the exercise until he could no longer perform the exercise. The subject was instructed to use only the arm which was being exercised.

3. When the subject reached the maximum weight that he could lift, four and one-half pounds were subtracted each time the subject performed the exercise until no electrical activity was apparent in the record for the opposite arm.

4. The electrodes attached to the rectus femoris were used to determine the voltage generated in this area when the subject again lifted, with his arm, the maximum weight which he was capable of lifting.

5. The records were obtained by photographing the wave of the oscilloscope with a 35-mm. camera.

Analysis

The analysis of the waves that were recorded from the unexercised limbs of the 17 subjects are presented here. The wave that, for the unexercised arm, had been recorded on a 35-mm. film was enlarged by means of a filmstrip projector.

The positive and negative spikes of the waves were recorded to the nearest 2.5 microvolts (represented by one-fourth of a square in Fig. 2). The microvoltage developed by the subject was found by computing the mean for the positive and negative spikes for all the weights that were lifted. Each subject

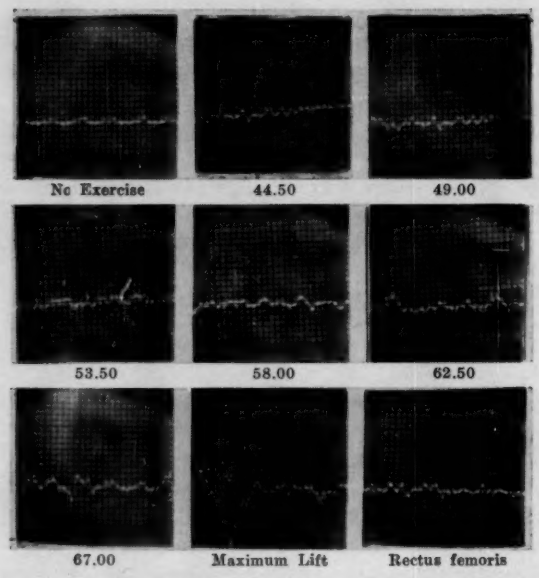

FIGURE II. Recording of Microvoltage for Unexercised Arm as Progressively Heavier Weights Were Added and Recording of Microvoltage for Thigh When Maximum Lift Was Executed by Arm.

lifted each weight, which he was capable of lifting, two times. There was little or no change in the electromyograph recordings between the first and second performances.

The microvoltages were plotted against the weights lifted. It was found that for each subject the microvoltage varied somewhat as the subject lifted more weight: however, the pattern showed an increase in microvoltage as the resistance was increased. The maximum microvoltage was developed at or near the time when the subject executed his maximum lift. The microvoltage developed in the rectus femoris when the maximum lift with the arm was executed was also noted on the plots, and it was found to be of smaller amplitude than that recorded from the unexercised arm.

The mean microvoltage for the 17 subjects was computed for each weight that was lifted, and these means were plotted on a graph (Figure III). The plots indicate that the electric potential increased with the increase in the weight lifted. Each subject's graph was then compared with the graph for all the subjects. None of the individual graphs follows, exactly, the graph for all the subjects, and the graphs for some subjects vary greatly from the graph for the group.

When the activity in the unexercised arm caused more than ten microvolts to be recorded—an amount that clearly indicated that a potential was being

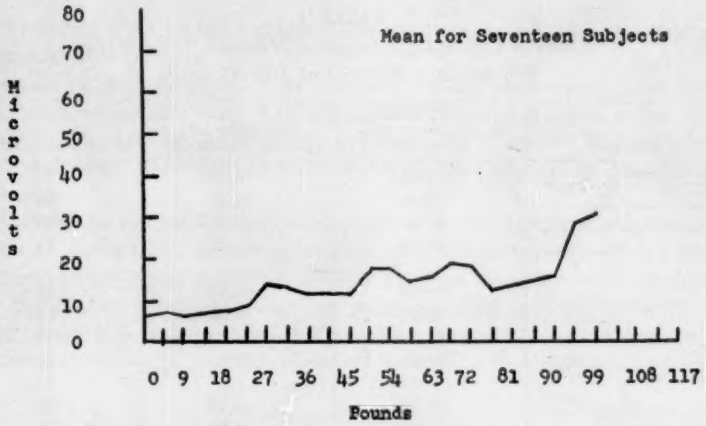

FIGURE III. Microvoltage and Resistance in Pounds (based on means for 17 subjects).

generated—the amount of weight that the subject was lifting was recorded. The percentage that this weight represented of the maximum weight lifted was computed. Then the mean of the percentages for the various weights lifted was found to the nearest one-tenth of a per cent (Table 1). It was found that, for all the subjects, 70.0 per cent of the maximum lift was required to cause a recording of ten microvolts. The range was from 18 to 94 per cent.

The subjects were then divided into two groups with the eight strongest subjects in one group and the eight weakest subjects in the second group. (One subject's maximum was not successfully recorded.) The mean of the maximum strengths was 32.50 pounds greater in the "strong group" than in the "weak group." The strong group used a mean of 61.32 per cent of their maximum strengths to elicit a recording of ten microvolts, while the weak group used an average of 84.54 per cent of their maximum strengths to obtain a similar recording in their unexercised arms.

It was evident that the weak group had to lift with a slightly greater percentage of their maximum strengths than did the strong group; however, there was a difference of only 8.94 pounds in the mean amounts of weight lifted by the two groups to elicit a response in their unexercised arms.

This result indicated that the strong person may elicit a response in an unexercised arm by using a smaller per cent of the total strength of his exercised arm, but a greater amount of the absolute strength than that used by a weak person.

The mean of the microvoltages recorded for the unexercised arms when all subjects exerted maximum effort was 30.4 microvolts. This amount was much less than that recorded when the subjects' exercised arms were tested

TABLE 1

Maximum Lift, and Percentage of Maximum Lift Needed To Obtain a Potential of Ten Microvolts

Subject	Pounds Lifted When Microvoltage Was Developed	Maximum Lift in Pounds	% of Maximum Lift
6	71.50	76.00	94
1	58.00	62.50	93
11	40.00	44.50	90
12	35.50	40.00	89
7	31.00	35.50	87
13	49.00	58.00	84
9	62.50	80.50	78
14	31.00	35.50	87
15	40.00	53.50	75
10	66.50	94.00	71
2	35.50	49.00	72
8	44.50	71.50	62
16	40.00	66.50	60
4	58.00	111.50	52
3	35.50	67.00	53
5	13.00	71.50	18
Mean	44.50	63.60	70.0

with no resistance. This indicated that more microvolts may be developed by active non-resistive exercise (or "muscle setting") than may be developed by heavy-resistance exercise of an opposite limb.

Summary

This study was undertaken to determine, by means of an electromyograph, the amount of electrical activity developed in one arm, which was not moved, when the opposite arm was exercised. The experiment was carried out by having each of 17 subjects lift with one hand weights which were increased four and one-half pounds for each lift. This procedure was continued until the subject executed his maximum lift.

Electrical activity was developed in the unexercised arm when the opposite arm was exercised, but the activity was of low order. The weights that the subjects had to lift in order to develop potentials of ten microvolts ranged from 18 to 94 per cent, with a mean of 70 per cent, of their maximum lifts. There seemed to be some relationship between the per cent of maximum strength needed to elicit microvoltages in unexercised body parts, since the eight weakest subjects in this experiment had to use a greater per cent of their maximum strengths than did the eight strongest subjects. It is also probable that the ability of a subject to relax an unused part of his body

would have an effect on the number of microvolts recorded. Additional study may resolve this question.

A mean of 30.4 microvolts was recorded for the unexercised arms when the subjects performed their maximum lifts with their opposite arms. This mean was less than the microvoltage developed when several of the subjects raised their arms (the ones unexercised in the maximum lifts) against no resistance.

When the maximum lift was performed with one arm, the microvoltage was also recorded for the rectus femoris on the opposite side of the body. The mean microvoltage recorded was less than the mean microvoltage developed in the unexercised arms when the maximum lifts were performed.

The results obtained from this study indicate that an exercise against strong resistance is necessary to elicit electrical potentials in an unexercised body part.

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(Submitted 11/12/57)

Football Starting Signals and Movement Times of High School and College Football Players

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Abstract

An apparatus was designed and constructed to measure movement times of football players. High school and college varsity football players were tested, using certain selected football starting signals. Rhythmic digit, rhythmic word-digit, non-rhythmic word-digit, and non-rhythmic color starting signals were used, and movement times for each starting signal were computed.

ALL FOOTBALL coaches agree that quick reaction time and movement to a starting signal is a major football fundamental. This agreement is epitomized by Bud Wilkinson, the very successful coach at the University of Oklahoma who states (13):

"The most important single fundamental of offensive football regardless of the system of play is the starting count. We know of no other single fundamental of the game which will pay bigger dividends than the proper execution of the starting count. It is worth many hours of practice time to the offensive team."

The starting signal provides the offensive team with the advantage of knowing when the ball will be snapped. This compensates for the rule which allows the defensive team to use their hands. The offensive success of a team in football depends in part on its ability to exploit the advantage allowed by the use of starting signals.

Many starting signals have been used in the attempt to find one that is most efficient. Both visual and auditory stimuli have been used. To the authors' knowledge, auditory signals are used exclusively by coaches today.

Though many starting signals are used, they may be classified into two general types. First, the starting signals delivered in cadence (rhythm) will be designated as rhythmic signals. An example of this signal has the quarterback counting, "One, two, three, four, five, etc." at a set rhythm. The ball is snapped on a predesignated number.

Minor variations of this type of starting signal find the substitution of a word-digit combination; (hut-one, hut-two, hut-three, etc.) or the substitution of colors (red, green, blue, orange, etc.). The offensive team can charge on any number, color, or word-digit, with the starting number, color, or word-digit varied enough to keep the defensive team off-balance.

The second general type of starting signals is the type given without a cadence—the non-rhythmic type. An example of a non-rhythmic signal, which is extensively used, is the word-digit signal "hut-one, hut-two, hut-three, etc.," given by the quarterback who varies the speed of his signal delivery from a fast to a slow, hesitating manner. The ball may be snapped and the offensive charge made on any "hut-two" signal, with the offensive team knowing the charging signal but only the quarterback knowing the rhythmic pattern he will use in "barking" the signals.

A variation of this system of starting signals is found in the use of colors (red, green, blue, etc.) substituted for the word-digit combination and given without a cadence by the quarterback. An important difference found in the color starting signal system is that only the quarterback knows when he is going to call the designated color. For example, in the huddle red is designated as the starting signal, but only the quarterback knows when he will give it. He might say blue, green, yellow, orange, red, or give red as first signal.

It was surmised from four recently published football coaching textbooks that the coaches who wrote the books favored some kind of rhythmic signal system. In contrast, Bud Wilkinson states that his teams use a non-rhythmic starting signal because he believes it largely eliminates the leaning of offensive players in anticipating the rhythmic signals and keeps the offensive players more alert because they do not know when the signal will be given. He states that this alertness aids them in charging faster. Mr. Wilkinson seems to imply, and many coaches agree, that the greater the concentration on the stimuli (starting signal) the faster the speed of reaction.

In searching the literature, the authors were unable to find any recent scientific study which attempted to find the starting signal or signals that were the fastest.

With the exception of the research conducted by Miles at Stanford University in the 1920's relative to this problem, there is apparently no scientific evidence to support any system of starting signals. Miles (9) conducted his research with a view of devising simple testing procedures for selecting varsity football players. His experiments attempted to find which auditory command would cause a quicker reaction. He used rhythmic and non-rhythmic starting signals at different rates of speed timed by a metronome. His results support the use of a rhythmic signal system.

Reaction-time studies related to athletes and athletics have been attempted generally to secure data that would provide coaches, and other individuals engaged in the selection of athletes, with some objective ways of predetermining athletic abilities or selecting athletes.

Reaction time in its strictest interpretation is the interval elapsing before a predetermined movement following a predetermined stimulus. Dawson, Karpovich, and Olson (5, 6, 10) have all defined reaction time in substantially the same terms.

Cottell (4) found that time of day, condition of the body, and number of times tested seemed to have little effect on reaction time. Reaction times of

analogous movements of different segments of the body, arms and legs, have no direct relationship, as Biese and Peasely (2) and Miles (9) found in their research. Fast flexion of the arm does not necessarily mean fast flexion of the leg.

Burpee and Stroll (3) and Snygg (11) both indicate that practical measures of reaction times in relation to definite athletic skills are generally lacking because of inadequate apparatus.

Keller (7) used 359 athletes in his study of quickness of bodily movements. He found a positive relationship between the ability to move the body quickly and the success in athletic activities.

Atwell and Elbel (1) found a tendency for reaction time to become faster with age in their study with high school and university students. Thompson and Nagle (12), in a preliminary study of university varsity football players, found a faster reaction time to a rhythmic count than to a non-rhythmic starting count.

The authors found that nearly all experiments on reaction time relating to athletics measured reaction time and motor (muscular) response as a more useful type of reaction time. In this study, the reaction time and motor response of taking an 18-inch step and hitting the contact plate after a predetermined signal will be designated as movement time.

This study is a report of the construction of an apparatus to accurately and scientifically measure movement time, and the report of the results obtained from the study of certain selected football starting signals.

Apparatus

To measure accurately and scientifically the differences in movement time to different starting signals, an apparatus was designed and constructed which would measure to 1/100 of a second the time required for an offensive player to respond to various football starting signals.

The essential items of equipment were two micro contact switches, relay, four 1½ volt dry cell batteries, standard electric clock,[1] wire and contact plate. The switches, relay, batteries, wire, and standard electric clock were secured through local commercial sources. The contact plate was designed by the authors and constructed in the Boston University machine shop.

One contact switch, which was used to start the clock, was held in the hand of the tester (A—Figure I). It was connected through the relay (C—Figure I) to the clock. Four dry cell batteries (1½ volt) supply 6 volts direct current to operate the clutch of the clock. The clock motor operates on a 115 volt, 60 cycle AC current supplied from any normal electrical outlet.

The electric clock was a manual reset type which recorded to the 1/100 of a second the elapsed time from the instant the tester (quarterback) pressed the contact switch (A) until the foot of the subject depressed the contact plate stopping the clock.

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[1] Standard Electric Time Company, Springfield, Mass.

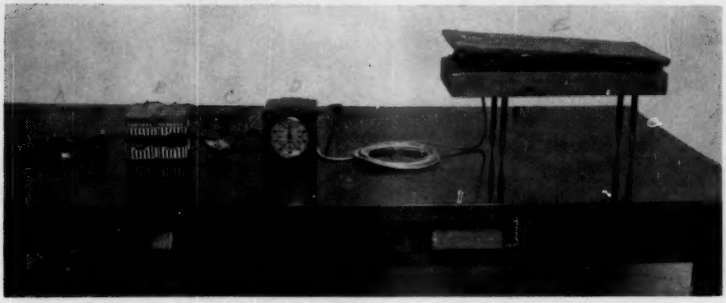

FIGURE I. Football Starting Signals Movement Time Apparatus.
(*Left to right*—A. Contact switch, B. Four 1½ volt dry cell batteries, C. Relay, D. Standard electric clock, E. Contact plate, mounted on two-inch oak plank.)

To contain the second switch, the one to stop the clock, it was necessary to construct a heavy, durable contact plate (E—Figure I). It had to be strong and durable enough to absorb the tremendous force of a charging subject when he hit the plate with his foot. Also, the contact plate had to be large enough to be easily contacted by the charging subject. The contact plate, 9 inches wide and 18 inches long, was designed, constructed, and found to be very satisfactory.

The contact plate was constructed of two sections of half-inch steel plate hinged at one end and mounted on a two-inch oak plank. The second switch was mounted in the middle of the plate approximately three inches from the unhinged end. Two steel stop flanges (E—Figure I) were placed between the plates. They allowed for a 3/16 inch depression of the switch spring. Snap wire contacts were connected to the switch in order that the wires could be removed during transit and storage. Two small circular springs located on each side (underside) of the plate near the unhinged end returned the plate to its original position after contact by the foot of the subject.

Methods and Procedures

All subjects were tested before their daily football practice. Every effort was made to approximate actual football conditions (Figure II). Players were tested individually in full football equipment after they had a thorough warm-up. The tester (quarterback) who gave the signals took a position behind the subject (Figure II) as would normally be the position under actual playing conditions. The subjects were not informed of their times nor were they allowed to watch others being tested.

Directions in the general testing procedure were given to small groups, four to six subjects, followed by a demonstration. Prior to individual testing each subject was given several practice trials.

A distance of 18 inches (Figure II) from the starting line to the contact plate was selected arbitrarily on the theory that the first step by a football player is usually a comparatively short step.

The starting signal was explained to each subject. After he was given the charging signal, he assumed a position with the feet in normal stance

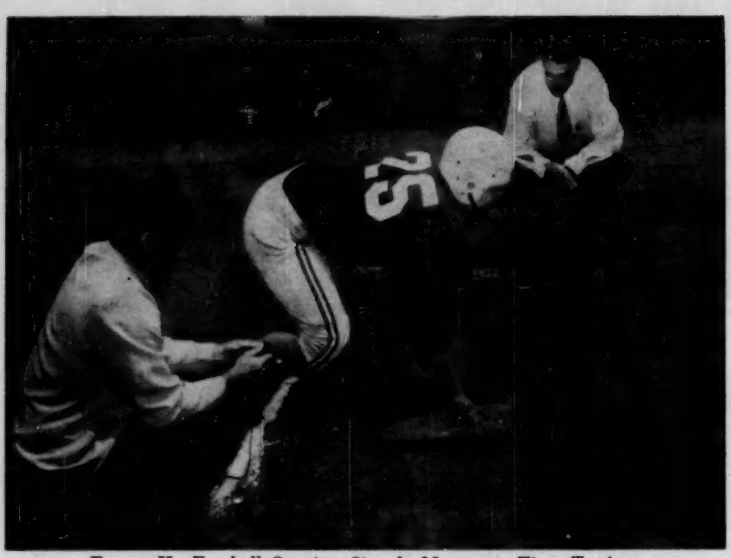

FIGURE II. Football Starting Signals Movement Time Testing.

position. The stance position used had one foot in advance of the other. Either the right or left foot, depending upon player preference, was placed on the starting line directly behind the contact plate. On the command "Ready," the subject dropped into his regular three-point offensive stance from which he was ready to charge on the designated starting signal.

The testing procedure had the tester (quarterback) calling the signals. Simultaneously with calling the starting signal, he pressed the contact switch in his hand to start the standard electric clock. The subject from his normal three-point stance reacted to the signal, charged forward as quickly as possible. Thus the time required for the subject to react and take one step (18 inches) to the contact plate was recorded in hundredths of a second. To insure a fast, continuous charge, the subjects were instructed to charge five yards beyond the contact plate.

The mean of the trials given a subject was considered his score. In the few instances in which a subject was leaning overly, anticipating a starting signal, or not ready to charge, was disregarded and another trial allowed. A trained recorder read and recorded the time and reset the clock to zero.

In the initial phase of the study done with the Boston University football squad, five trials were given with each starting signal. An analysis of the results found the coefficient of correlation to be $r = .86$ using three test scores in comparison with five scores. Therefore, in the latter phase of the study, only three trials were given.

All subjects tested, high school and college, were football lettermen and members of varsity football squads.

Reliabilities of the tests were established by a test-retest procedure. With seven University varsity football players, a retest of 35 trials for each signal found a correlation of test-retest results of rhythmic digit starting signal was $r = .71$ and $r = .52$ with non-rhythmic word digit starting signal.

Results

Phase I of the study was conducted with 43 Boston University varsity football players. Two starting signals were used: Rhythmic digit signal (one, two, three, four, etc.) and a non-rhythmic word-digit signal (hut-two, hut-two, hut-two) given in a non-rhythmical manner. Every subject was tested five times on each starting signal. Signals were varied as a quarterback would vary them under actual game conditions.

In the rhythmic digit starting signal, the tester (quarterback) called the numbers in certain cadence (rhythm). The subject was told the number on which he was to charge each time he repeated the test.

The non-rhythmic word-digit starting signal was "hut-two, hut-two" given in a non-rhythmical manner. The subject was told the certain "hut-two" on which he was to charge, for example, the second hut-two. As under actual game conditions, the cadence was varied from fast to a slow cadence or a combination of the two.

TABLE 1

Rhythmic and Non-Rhythmic Starting Signals and Movement Time Means of Varsity College Football Players

Test	Subjects	Number of Trials	Mean[1]	Standard Deviation	t	Level of Significance
Rhythmic digit	43	215	.51	.062	8.77	1%
Non-rhythmic word-digit	43	215	.56	.056		

[1] Time expressed in hundredths of a second.

Table 1 indicates that the football players tested in this phase move more quickly to the number rhythmic type of starting signal than to the non-rhythmic (hut-two, hut-two) by .06 of a second. The difference in the results were significant at the 1 per cent level (8).

Phase II of the study involved 40 New Hampshire high school football lettermen. Three starting signals were used: rhythmic digit (one, two, three) starting signals, non-rhythmic word-digit system (hut-two, hut-two) both of which have been previously described, and the non-rhythmic color starting signal (red, green, orange, etc.).

The non-rhythmic color starting signal used four colors—red, blue, white, and green—as they were readily distinguished from each other when spoken.

The subject was instructed to charge on a given color signal, red for example. The tester (quarterback) gave the starting signals in a non-rhythmic manner and only he knew when the designated charging color was to be called. Colors could be used one or more times.

Table 2 indicates the rhythm starting signal results in the fastest movement time (.54 seconds). The non-rhythm starting signal was .05 a second slower.

TABLE 2

Rhythmic, Non-Rhythmic and Non-Rhythmic Color Starting Signals and Movement Time[1] Means of Varsity High School Football Players

Starting Signals	Subjects	Trials	Mean	Standard Deviation	t	Level of Significance
Rhythmic digit	40	120	.54	.068	5.56	1%
Non-rhythmic word-digit	40	120	.59	.072		
Rhythmic digit	40	120	.54	.068	13.03	1%
Non-rhythmic color	40	120	.66	.072		
Non-rhythmic word-digit	40	120	.59	.072	7.52	1%
Non-rhythmic color	40	120	.66	.072		

[1] Time expressed in hundredths of a second.

A much slower movement time (.66 seconds)—.14 seconds slower than the rhythmic type and .07 slower than non-rhythmic type—was recorded for the non-rhythmic color starting signal. A comparison of the results of the rhythmic digit—non-rhythmic word-digit, rhythmic digit—non-rhythmic color, and non-rhythmic word digit—non-rhythmic color found all of the results to be significant at the 1 per cent level of significance (8).

As a rule, football coaches generally use their fastest players, quickest reactors, for the backfield positions. Table 3 indicates that both high school and college backs have quicker movement times than linemen.

College football players, backs and linemen, had consistently faster movement times than high school backs and linemen (Table 3). Two factors

TABLE 3

College and High School Football Players (Backs and Linemen) Movement Time Means to Selected Football Starting Signals

Signals	Player	Subjects		Trials	Mean	Standard Deviation
Rhythmic digit	Backs	High	15	45	.54	.068
		College	16	80	.52	.034
	Linemen	High	25	75	.54	.068
		College	27	135	.50	.040
Non-rhythmic word-digit	Backs	High	15	45	.57	.063
		College	16	80	.56	.044
	Linemen	High	25	75	.64	.073
		College	25	125	.56	.035

deserve consideration in the explanation of these results. The college players are a more select group, being made up entirely of scholarship players. Secondly, reaction time decreases with age up to a certain age. This may also be a factor.

Discussion

It is a generally accepted physiological fact that when an individual concentrates on the stimulus (starting signal) (5) his reaction time is slower than it is when he concentrates on the response to that stimulus.

Applying this physiological principle to football, we assume that a player would be able to start (charge) faster when he is concentrating on the response (charge) rather than on the stimulus (starting signal) (5).

With the rhythmic digit system of calling signals, the offensive player can concentrate more on his response (charge) since he knows the cadence (rhythm) and the starting number. His concentration can be largely on his assignment for the particular play and secondarily on the starting signal.

The non-rhythmic starting signals require the offensive player to concentrate more on the starting signal (stimulus) because there is no set cadence to the signals and the starting signal cannot be anticipated as readily. In the non-rhythmic word-digit starting signals (hut-two, hut-two) the offensive player knows when the starting signal will occur in the signal sequence but he does not know the rhythm.

In the non-rhythmic color system, neither the rhythm, or the time when the starting signal will be given, is known to any player other than the quarterback. This system demands the greatest concentration and theoretically this system would result in the slowest reaction time of all the starting signals discussed.

The results of this study confirm these assumptions (5). Both groups (Table 3) reacted more quickly to the starting signals which allowed the subjects to concentrate on the response rather than the stimulus. The rhythmic digit starting signals permitted the fastest movements—.51 second for college players and .54 second for high school football players.

Non-rhythmic word-digit starting signals require more concentration on the stimulus (5) because the tester (quarterback) can vary the cadence. This starting signal resulted in slower movements in both University and high school football players (Table 3).

The non-rhythmic color starting signals were found to be the slowest (.66 second) in high school football players. Some preliminary testing of college players has further substantiated these results.

Slower reaction time to this type of starting signal is not unexpected, as the subject has to concentrate not only on the varying rhythm of the signals but on when the color to start (charge) will be given.

Additional studies in this area, with a second clock in the circuit, are being planned. The first clock would measure the strict reaction time from the starting signal to the start of the movement. Movement time of the sub-

ject's foot from its starting point to the contact plate (18 inches) would be recorded on a second clock. Then we could be sure what the lapse of time is due to: reaction time or speed of movement.

All football coaches are interested in force—Force-Mass (weight) × Acceleration. If one starting signal produced faster acceleration (movement) then it is the signal that should be used. Additional research will further establish this fact.

Summary and Conclusions

A reliable and accurate apparatus was devised and constructed to measure the movement time (18 inches) of varsity college and high school football players to selected starting signals. Rhythmic digit starting signals were found to result in the fastest movement times; the mean of the college group was .51 seconds and of the high school group, .54 seconds. Non-rhythmic word-digit and non-rhythmic color signals were investigated and found to result in slower reaction and speed of movement times. Statistical comparisons of the means of all starting signals found all results to be significant at the 1 per cent level.

In light of the results of this study, the belief that non-rhythmic and color starting signals allow for the fastest charge is untenable. Additional research using other football starting signals is needed.

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(Submitted 10/9/57)

Effect of Warm-Up Upon Physical Performance in Selected Activities

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Abstract

Five groups of subjects were tested to determine if warm-up affected performance in speed and endurance in swimming, accuracy in basketball foul-shooting, accuracy in bowling, speed and accuracy in typing, and strength of softball players. No evidence was found of improvement from informal warm-up immediately preceding testing in swimming, typing, or strength. Formal warm-up did improve group performance in speed and endurance in swimming, accuracy in basketball foul-shooting, and accuracy in bowling; however, no significant difference was noted in the performance of the typists after participating in a formal warm-up prior to the testing.

COACHES and physical educators have been concerned for many years about what they considered to be adequate warm-up before attempting vigorous physical performance.

Many coaches advocate an extensive warm-up activity for their athletes immediately preceding practice or competition. The reasons advanced by the various coaches for warming-up procedures are numerous. Evidence for such thinking may be found in the conclusions of various experiments (1, 2, 3, 6, 9, 13, 14, 15, 16).

Coaches of almost every athletic activity assume that warming-up procedures are beneficial and factual; however, a few athletes and coaches are inclined to question the value of extensive preliminary warm-up activity on the basis that the athlete may have already exhausted a needed part of his energy when the time arrives for the major performance.

Recently, the value of warming-up has been seriously challenged by certain research workers in the field. Publication of their findings on lack of value from warm-up has aroused considerable discussion of this problem (5, 7, 9, 10, 17).

Purposes of the Study

The purposes of this study were to determine whether warm-up affected speed, endurance, accuracy, and strength in various activities; more specifically, whether warm-up affected: (a) speed in swimming a 30-yard sprint and endurance in swimming for a 5-minute period; (b) accuracy in basketball foul-shooting; (c) accuracy in bowling; (d) speed and accuracy in typing; and (e) strength of the legs.

Definition of Terms Used

Formal warm-up. Exercises in which the movements are those that imitate the activity for which the performer is getting ready (9).

Informal warm-up. Exercises in which the movements are the general, free movements (such as swinging the arms about and stationary running) undertaken solely for raising the temperature of the muscles (9).

Procedure

PART I: SWIMMING

The subjects of the experiment in this activity area were 85 male students between the ages of 17 and 28. They were enrolled in five different classes of an eight-week advanced swimming course in the required physical education program at Pennsylvania State University.

The swimming was done in the Glennland swimming pool, which measured 90 feet by 45 feet. The average air temperature within the pool area for the eight weeks was 82.22° F. The average water temperature throughout the entire experiment was 85.92° F.

During the first class meeting of the five classes in which it was hoped adequate volunteers for the experiment could be secured, the course contents were reviewed, and a short introductory talk was given.

Every student volunteered to participate in the study. At the first meeting of each class, members were timed separately for the 30-yard sprint, then tested on the 5-minute endurance swim.

Classes were dismissed after the testing was completed. Next, lists were made, assigning students to one of the test events for the rest of the course. The swimmers were divided into two groups—51 sprint swimmers and 34 endurance swimmers—and the lists were prepared for the second class meeting. This larger list was separated into five lists, one for each class section.

It was decided to award ten dollars to the individual with the fastest time in a 30-yard sprint swim and another ten dollars to the individual with the most laps in the 5-minute endurance swim. In addition to the ten dollar awards, a letter grade of "A" was given to all individuals that participated in the study; however, the participants in the experiment had to follow all rules and regulations of the experiment and all regulations pertaining to regular swimming classes at the University.

Before every class for four weeks, each student was required to do one of the training routines described below; however, the routine used depended upon the group to which an individual had been assigned.

ROUTINES.

Sprint swimmers.

1. Two 60-yard sprints at three quarters speed, using only the American crawl stroke.
2. Flutter kick for 60-yards, using no arm stroke.
3. Arm pull for 60-yards, using no leg kick.
4. One 30-yard sprint at full speed, using the American crawl stroke.
5. Two 60-yard sprints at full speed, using the American crawl stroke.

Endurance swimmers.

1. Two 60-yard sprints at three quarters speed, using only the American crawl stroke.
2. Flutter kick for 60-yards, using no arm stroke.
3. Arm pull for 60-yards, using no leg kick.

4. One 30-yard sprint at full speed, using the American crawl stroke.
5. A five-minute endurance swim at full speed, using the American crawl stroke.

The formal classes were dismissed ten minutes early, but all of the students were kept this ten minutes and five additional minutes. These 15 minutes were used for a rest period and for testing the subjects.

A five-minute rest period was provided for all of the subjects at the completion of the formal class period. All sat on benches while resting. In the next ten minutes, the endurance swimmers swam a 5-minute, timed endurance swim. The swimmers of the sprint group counted the laps, of individuals assigned to them for that purpose, in the endurance swim. The laps swum by each individual were recorded. Then the sprint swimmers were timed individually for the 30-yard sprint. After each sprint swimmer had swum, his time was recorded. A little leeway in time was available so that this testing could always be completed even if it took a few more minutes.

At the end of the first four weeks, the cumulative records of the endurance and speed swimmers were reviewed. The individuals in the study whose successive records at this time did not approximate a plateau were dropped from the study. Seventeen sprint swimmers and eight endurance swimmers were dropped from the study because of inconsistency in their times and number of laps swum. This dropping of subjects left a total of 34 sprint swimmers and 26 endurance swimmers in the experiment.

The last four weeks of the experiment were devoted to testing the subjects of both groups with warm-up and with no warm-up. Each group was tested six times with no warm-up, three times with a formal warm-up, and three times with an informal warm-up. The order of testing was as follows: no warm-up, formal warm-up, no warm-up; formal warm-up, no warm-up, formal warm-up; no warm-up, informal warm-up, no warm-up; and informal warm-up, no warm-up, informal warm-up. Each individual had a total of six no-warm-up scores and six warm-up scores, accumulated by swimming 12 different times.

Methods of testing when no warm-up preceded the performance (during last four weeks). When the subjects entered the dressing room, they undressed and went into the pool area immediately. They did not take a shower. After entering the pool area, the swimmers were not allowed to participate in any form of activity or go into the water until the test was to be administered. The only activity that the subjects had prior to testing on the no-warm-up days was the walking to and from class.

Both the sprint and endurance groups of subjects were required to rest for five minutes by sitting in an upright position on benches provided for them. They sat, instead of lying in a prone position, because the conditions in the pool area prohibited the students' lying down. Each individual draped a towel around his shoulders.

After the 5-minute rest period had expired, the speed swimmers were then tested separately for the 30-yard sprint. The time in seconds required to swim the 30-yard sprint was recorded for each individual.

The endurance swimmers were then tested for the 5-minute endurance swim. The sprint swimmers counted the laps for the endurance swimmers. The number of laps each endurance swimmer had swum during the 5 minutes was recorded.

After the testing was completed, the class went through the training routines first; then were given the regular instruction in swimming. Starting with the seventh week, the training routines were omitted.

Methods of formal warm-up and testing after warm-up (fifth and sixth week). The sprint and endurance swimmers began their warming-up immediately after undressing. Each individual was required to take a hot shower for three minutes. He then went into the pool and did one of the following routines, depending upon the group to which he had been assigned:

Sprint swimmers

1. Arm pull for 30 yards, using no leg lick.
2. Flutter kick for 30 yards, using no arm stroke.
3. One 60-yard sprint at three-quarters speed, using the American crawl stroke.

Endurance swimmers

1. Arm pull for 30 yards, using no leg kick.
2. Flutter kick for 30 yards, using no arm stroke.
3. A two and one-half minute swim at three-quarters speed, using the American crawl stroke.

After the swimmers had completed their warm-up, they were required to rest in a sitting position for five minutes with towels around their shoulders. Each individual was then allowed to submerge his entire body in the water immediately preceding the testing.

The sprint swimmers were tested first for the 30-yard sprint. Their times were recorded in seconds.

The endurance swimmers were then timed for the 5-minute endurance swim. The sprint swimmers again counted the laps for them. The laps swum were recorded for each individual. During the remainder of the period, after completion of tests, the procedures for this group included training followed by instruction in swimming.

Methods of informal warm-up and testing after warm-up (seventh and eighth week). Both speed and endurance groups, upon arriving at the pool and undressing, omitted the shower and went directly into the pool area. Both groups were put through their warm-up procedures simultaneously. The instructor kept the subjects together in their exercises by counting cadence. The warm-up consisted of a series of calisthenic exercises involving vigorous use of most of the large muscles of the body. The exercises were taken from *Calisthenics* by S. C. Staley (19, *pp. 143, 146, 150*), *Physical Conditioning* by Stafford and Duncan (18, *pp. 56-59*), and *Swimming* by Kiphuth (11, *pp. 39, 47, 55*).

After the subjects had completed their exercises, they draped towels around their shoulders and rested in a sitting position for five minutes.

The sprint swimmers were then tested for the 30-yard sprint, and their times were recorded in seconds.

The endurance swimmers were tested for the 5-minute endurance swim, after the sprint swimmers had been tested. The sprint swimmers counted the laps for the endurance swimmers. The laps each endurance swimmer had swum during the 5 minutes were recorded.

The remainder of the class period, after completion of testing, was spent in swimming instruction.

PART II: BASKETBALL

The subjects of this phase of the study were 20 freshmen basketball players who were attending Pennsylvania State University. The ages of the players ranged from 18 to 23 years. These players had completed 62 days of basketball practice before the testing phase of this experiment began.

The subjects were tested on Monday, Tuesday, Thursday, and Friday afternoons between 4 and 5:30 o'clock. The freshmen team had games scheduled on Wednesdays; therefore, any testing which could have been done on this day was eliminated. No testing was done on the weekends because the basketball team did not practice on Saturday or Sunday.

Each player was allowed to use any form or type of shot he wished in shooting his 20 foul shots, as long as he maintained the same shooting style or form throughout the entire testing program.

Each subject selected a spot on the foul line from which to begin his shooting. He did not have to move from that spot during the testing because the ball was passed to him by "feeders."

As the subjects shot their 20 foul shots, a recorder kept a tally of the number of shots each individual attempted, made, and missed.

Before the testing for warm-up and no warm-up began, each subject had to shoot 20 foul shots per day for eight consecutive testing days. This foul shooting was done to determine the consistency of the subjects in the number of successful foul tries made from day to day.

After an approximated plateau had been established for each basketball player, the testing without warm-up, and preceded by a warm-up, began. Each player was tested three times with no warm-up and three times with a formal warm-up. The order of testing for no warm-up and warm-up involved alternating days.

Methods of testing performances without preceding warm-up. On the no-warm-up testing days, each subject was tested on his 20 foul shots immediately after he had dressed for practice and entered the gymnasium. The only activity that any individual had on no-warm-up testing days was the walking to and from classes.

Methods of formal warm-up and testing after warm-up. The procedures that each ball player followed on warm-up days, prior to his testing on 20 foul shots, were a combination of formal and informal types of warming-up activities. The warm-up consisted of the following routine:

1. General floor shooting for ten minutes.
2. Passing for three minutes.
3. Shooting of ten foul shots.

Immediately after each individual had completed his warm-up, he took his 20-foul-shot test.

PART III: BOWLING

The Staff Bowling League whose members bowled every Tuesday night during the week was composed of six teams; five members, plus substitutes, comprised a team.

The Faculty-Staff Bowling League whose members bowled every Friday night during the week was also composed of six teams; five members, plus substitutes, comprised a team.

The individual team members of both leagues bowled three games a night between 6:15 P.M. and 8:45 P.M. Records of both leagues were obtained on January 19, 1957, and sorted thoroughly for subjects. The records of all those bowlers who had bowled 45 games in league competition between September 25, 1956, and January 18, 1957, were used for this study. By selecting from both leagues, the writer was able to secure 56 bowlers who had bowled the 45 games. The age span of these selecied bowlers was from 22 to 56 years of age.

The mean of the 45 games that each individual bowled was calculated and considered as that individual's plateau. After the mean for establishing the various bowlers' plateaus was computed, the record books were returned to the league secretaries. The record books were collected again on March 30, 1957, after a ten-week period had elapsed.

The records were again processed for the 56 bowlers who had bowled 45 games by January 18. All 56 bowlers had bowled each league night during the ten-week period from January 22, 1957, to March 29, 1957.

The warm-up effects and no warm-up effects were established by using the records of the ten-week period and recording the first-game scores of each week as no warm-up and by recording the second game scores of each week as formal warm-up. By this means, a total of ten no-warm-up scores and ten formal warm-up scores of each individual was secured.

Methods of testing performances without preceding warm-up. The first-game scores that each individual had bowled were used as each bowler's test of no warm-up. Each bowler had a total of ten scores for performance without warm-up.

Methods of formal warm-up and testing after warm-up. The second-game scores that each individual had bowled were used as each bowler's test of bowling after warm-up. In other words, the first game that each bowler bowled on these nights was used as a formal warm-up for his second game. A total of ten scores for bowling after warm-up was obtained for each bowler.

PART IV: TYPING

The subjects of this phase of the study were 19 female students who were enrolled in a Typing II Course. The ages of the subjects ranged from 18 to 22 years. Each student had completed one semester of typing prior to enrolling in this course.

During the testing, the subjects were started by their instructor with the following command: "Eyes on Copy!"; "Fingers on Keyboard!"; "Start Typing!"

A stop-watch calibrated in five-tenths of a second was used by the instructor for timing. As the instructor gave the command, "Start Typing!," she started the stop-watch.

When five minutes of timed typing had elapsed, the instructor gave the command, "Stop Typing!" All of the subjects immediately stopped typing. The subjects then checked their copies for errors and put the gross number of standard words per minute and number of errors in the upper right-hand corner of their papers.

The papers were turned in and then rechecked to insure that no errors had been made in the individual computations. These scores were then recorded.

Five-minute speed and accuracy tests were given the subjects between February 4, 1957, and April 27, 1957. These tests were given and administered by the instructor of the class as partial requirements of the course.

The scores made on these particular test papers were also used to determine when the subjects had become consistent or had reached an approximated plateau in their timed writings. By April 27, only 13 subjects had reached what was established as a plateau and so were selected for the study. The other six subjects were dropped from the study at this time.

The students were tested each day, alternating from day to day between no warm-up and warm-up. Each group was tested six times with no warm-up, three times with a formal warm-up, and three times with an informal warm-up. The order of testing was as follows: no warm-up, formal warm-up, no warm-up, formal warm-up, no warm-up, formal warm-up, no warm-up, informal warm-up, no warm-up, informal warm-up, no warm-up, and informal warm-up. Each individual had a total of six no warm-up scores and six warm-up scores, accumulated by typing 12 different times. The actual testing phase of the study ran from April 29 to May 15.

After the subjects had reached an approximated plateau, various exercises with nearly the same degree of difficulty were selected for testing the subjects for performance with no warm-up and with warm-up. Syllabic intensity was the basis for selecting each exercise. These exercises were taken from Hodel and Phelan (8, *pp. 16-21, 25-33, 37-42, 49-51, 58-60, 64-72*).

The average syllabic intensity for the six no warm-up exercises was 1.37. For the formal and informal warm-up exercises, the average syllabic intensity was also 1.37.

Methods of testing performances without preceding warm-up. The subjects upon reporting to class were tested immediately as a group, for performance without warm-up. The subjects were not exposed to any type of activity, prior to this testing, which might have affected their timed writings in typing.

Methods of formal warm-up and testing after warm-up. The formal warm-up consisted of actually typing a preparatory typing drill for three minutes. These drills were made up in such a manner that the subjects were required

to use almost every key on the typewriter. These drills—Preparatory Drills 126, 127, and 130—were taken from *College Typewriting* (12) and were used as formal warm-up for the testing. The subjects were tested on the 5-minute timed writing immediately after completing their formal warm-up.

Methods of informal warm-up and testing after warm-up. The informal warm-up consisted of three minutes of finger calisthenics. The exercises were as follows:

Exercise 1. The subjects placed the fingers of their right hand in the palm of the left hand. The fingers on the right hand were then spread apart and bent back by applying pressure from the palm of the left hand. This exercise was also used for the fingers of the left hand. The subjects did this exercise with each hand for 15 seconds or a total of 30 seconds.

Exercise 2. The subjects held their hands in a pronated position directly in front of their bodies with their arms bent at the elbows. The fingers and thumbs of each hand were held together. On the count of 1, the subjects spread their fingers and stretched them vigorously. On the count of 2, the subjects brought their fingers and thumbs together again. This exercise was done for 30 seconds.

Exercise 3. The subjects placed both hands on their desks. Their fingers were together. On the count of 1, the subjects lifted their fingers from the desk and kept their palms flat against the top of the desks. On the count of 2, the subjects spread their fingers as far apart as possible. On the count of 3, the fingers were placed together again. The fingers were returned to the starting position with the entire hand flat on the desk. This exercise lasted for 30 seconds.

Exercise 4. Rubber balls the size of a paddle ball, in diameter, were given to the subjects. The subjects placed the balls in the palms of their hands and, on the count of 1, squeezed the balls tightly with their fingers. On the count of 2, the subjects relaxed their fingers and spread them apart, keeping the balls in the palms of their hands. Sixty seconds was the allotted time for this exercise.

Exercise 5. The subjects shook their hands and fingers vigorously for 30 seconds.

The subjects were then tested on the 5-minute timed writing immediately after they had completed their informal warm-up.

PART V: STRENGTH

The testing for strength was conducted on 20 male subjects enrolled in the required physical education program at The Pennsylvania State University. The ages of these students ranged from 18 to 23. These students were enrolled in a softball class.

The leg dynamometer was the apparatus used for testing strength in this phase of the experiment. The procedures for using the leg dynamometer with a belt were those described by Clarke (4, *pp. 159, 161-162*).

At the beginning of each class meeting, for four weeks, each of the subjects was tested for leg extensor strength on the leg dynamometer. The amount of

the poundage pulled by each subject as indicated on the dynamometer was recorded at each successive class meeting in order to establish the consistency, if any, of a subject.

After the preliminary testing, the subjects were tested on the leg dynamometer on alternating days without warm-up and with warm-up preceding the test. Each subject was tested three times without a warm-up and three times with a warm-up.

Methods of testing performances without preceding warm-up. The subjects reported to class after they had dressed in their gym costume. Each individual was then tested on the leg dynamometer. None of the subjects had any activity prior to the testing, except for walking to and from classes.

Methods of informal warm-up and testing after warm-up. When all of the subjects had reported to class, they were required to do vigorous calisthenics as a general warm-up. Each subject did the warm-up exercises separately, prior to being tested for leg strength. The exercises were taken from *Physical Conditioning* by Stafford and Duncan (20, *pp. 56-59*).

Analysis of Data

PART I: SWIMMING

Speed swimming. The scores of the 34 speed swimmers were expressed in number of seconds required to swim 30 yards. The mean time of these students when they warmed-up *formally* was .95 seconds faster than when they did not warm-up. This difference has a critical ratio of 3.96 (between the mean times of students when they warmed-up *formally* and when they did not warm-up). This critical ratio indicated that there was a significant difference between performance with no warm-up and performance after formal warm-up in speed of swimming 30 yards; i.e., formal warm-up would seem to be an important factor in speed of swimming.

A critical ratio of 1.68 was obtained between the mean times of students when they warmed-up *informally* and when they did not warm-up in swimming 30 yards. This critical ratio indicated that there was not a statistically significant difference between performance without warm-up and performance after *informal* warm-up in sprint swimming for a distance of 30 yards.

Twenty-seven of the 34 speed swimmers swam from .1 of a second to 3.2 of a second faster after participating in a formal warm-up prior to testing than when they had no preceding warm-up. Seven of the 34 subjects swam from .2 of a second to .9 of a second slower after participating in a formal warm-up prior to testing than they did with no preceding warm-up.

Twenty-one of the 34 speed swimmers swam from .1 of a second to 2.2 of a second faster after participating in an informal warm-up prior to testing than they swam with no preceding warm-up. Eleven of the 34 subjects swam from .1 of a second to 1.6 of a second slower after participating in an informal warm-up prior to testing than they swam with no preceding warm-up. Two of the speed swimmers had the same times after participating in an informal warm-up as they did with no warm-up.

TABLE 1

Critical Ratios Between Mean Performance Scores of 34 Speed Swimmers Without Warm-up and With Warm-up

Performance	Time in Seconds				
	Mean Total for Three Trials	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	57.94	9.92	1.70	.99	3.96*
Formal warm-up	56.99	10.12	1.74		
No warm-up	57.79	10.19	1.75	.99	1.68**
Informal warm-up	57.42	10.25	1.76		

*Significant beyond the 1 per cent level of confidence.
**Not significant at the 5 per cent level of confidence.

Endurance swimming. The endurance swimmers as a group swam 1.27 laps farther after participating in a formal warm-up than they swam without warming-up. A critical ratio of 2.19 was obtained between the performance scores without warm-up and performance scores with *formal* warm-up in number of laps swum by 26 endurance swimmers for the 5-minute endurance swim. This critical ratio indicated that there was significant difference in endurance swimming after participating in a formal warm-up, and endurance swimming without any warm-up; i.e., *formal* warm-up would seem to be an important factor in endurance swimming.

A critical ratio of only .56 was obtained between the scores without warm-up and those after *informal* warm-up, expressed in number of laps swum by the endurance swimmers. This critical ratio indicates that there was no significant difference in the performance after an *informal* warm-up and without any warm-up.

Fourteen of the 26 endurance swimmers swam from one to six laps more after participating in a formal warm-up prior to testing than they swam with no preceding warm-up. Eight of the 26 endurance swimmers swam from one to three laps less after participating in a formal warm-up preceding the testing than they swam without any warm-up. Four of the endurance swimmers swam the same number of laps after participating in a formal warm-up preceding testing as they swam with no preceding warm-up.

Fourteen of the 26 endurance swimmers swam from one to four laps more after participating in an informal warm-up prior to testing than they swam with no preceding warm-up. Seven of the 26 endurance swimmers swam from one to two laps less after participating in an informal warm-up preceding the testing than they swam without any warm-up. Five of the endurance swimmers swam the same number of laps after participating in an informal warm-up preceding testing as they swam with no preceding warm-up.

TABLE 2

Critical Ratios Between Mean Performance Scores of 26 Endurance Swimmers Without Warm-up and With Warm-up

Performance	Number of Laps				
	Mean Total for Three Trials	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	70.85	10.51	2.06	.96	2.19*
Formal warm-up	72.12	10.16	1.99		
No warm-up	70.35	10.22	2.00	.99	.56**
Informal warm-up	70.88	10.60	2.08		

*Significant beyond the 5 per cent level of confidence.
**Not significant at the 5 per cent level of confidence.

PART II: BASKETBALL

A critical ratio of 9.07 was obtained between the performance scores without preceding warm-up and performance scores after formal warm-up, in foul shots made by 20 basketball players. This critical ratio was highly significant (1 per cent level of confidence) and indicated that formal warm-up was important for accuracy in foul shooting basketball.

All of the 20 basketball subjects made from two to 14 baskets more after participating in a formal warm-up than they made with no warm-up prior to testing.

TABLE 3

Critical Ratio Between Mean Performance Scores of 20 Basketball Players Tested for Accuracy Without Warm-up and With Warm-up

Performance	Foul Shots Made				
	Mean Total for 60 Free Throws	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	37.55	5.03	1.13	.75	9.07*
Formal warm-up	44.35	4.05	.91		

*Significant beyond the 1 per cent level of confidence.

PART III: BOWLING

The mean score of the bowlers after a formal warm-up was a total pin fall of 37.43 pins higher than without a warm-up.

A critical ratio of 2.94 was obtained between the scores of no warm-up and formal warm-up in bowling by 56 experienced bowlers. This critical ratio was significant beyond the 1 per cent level of confidence and indicated that formal warm-up may be an important factor in accuracy in bowling.

Thirty-six of the 56 bowlers scored from 19 pins to 249 pins more, in the total of ten games, with a formal warm-up prior to testing, than they scored in ten games with no preceding warm-up. Twenty of the 56 bowlers bowled

from 6 pins to 216 pins less, in the total of ten games, after a formal warm-up, than they bowled in ten games without any warm-up.

TABLE 4

Critical Ratio Between Mean Performance Scores of 56 Bowlers Tested for Accuracy Without Warm-up and With Warm-up

Performance	Bowling Scores				
	Mean Total for Ten Games	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	1418.43	164.68	22.02	.83	2.94*
Formal warm-up	1455.86	161.51	21.59		

*Significant beyond the 1 per cent level of confidence.

PART IV: TYPING

Speed in typing. An insignificant critical ratio of .53 was obtained for the difference between performance scores without preceding warm-up and performance scores after *formal* warm-up, in number of words typed per minute by 13 typists. This critical ratio indicated that there was no significant difference in typing speed without preliminary warm-up and with preliminary formal warm-up.

A critical ratio of 1.92 was obtained for the difference between the speed of typing scores without preliminary warm-up and with preliminary *informal* warm-up, in terms of words per minute. This critical ratio is significant only at the 6 per cent level of confidence, a level so low that real value cannot be assumed.

Eight of the 13 typists typed from three to 18 words more after participating in a formal warm-up prior to testing than they typed with no preceding warm-up. Four of the 13 typists typed from one to 20 words less after participating in a formal warm-up preceding the testing than they typed without any warm-up. One of the typists typed the same number of words after participating in a formal warm-up preceding testing as she typed with no preceding warm-up.

Nine of the 13 typists typed from one to nine words more after participating in an informal warm-up prior to testing than they typed with no preceding warm-up. Three of the 13 typists typed from three to five words less after participating in an informal warm-up preceding the testing than they typed without any warm-up. One of the typists typed the same number of words after participating in an informal warm-up as she typed with no preceding warm-up.

Accuracy in typing. A critical ratio of 1.35 was obtained between the accuracy scores without preliminary warm-up and accuracy scores preceded by *formal warm-up* (13 typists). This critical ratio is not significant at the 5 per cent level of confidence; hence, no real difference could be assumed in regard to value of warm-up for accuracy in typing.

TABLE 5

Critical Ratios Between Mean Performance Scores of 13 Typists Tested for Speed Without Warm-up and With Warm-up

Performance	Number of Words per Minute				
	Mean Total for Three Trials	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	172.38	24.29	6.73	.93	.53*
Formal warm-up	173.69	23.63	6.55		
No warm-up	175.77	25.12	6.96	.98	1.92**
Informal warm-up	178.46	25.11	6.96		

*Not significant at the 5 per cent level of confidence.
**Not significant at the 5 per cent level of confidence.

A critical ratio of .75, obtained between the accuracy scores without preliminary warm-up as compared with those preceded by an *informal* warm-up, indicated no significant difference; i.e., a preliminary informal warm-up does not improve accuracy.

Four of the 13 typists typed from two to 12 errors less after participating in a formal warm-up prior to testing than they typed with no preceding warm-up. Nine of the 13 typists typed from one to 14 errors more after participating in a formal warm-up preceding the testing than they typed without any warm-up.

Five of the 13 typists typed from two to 22 errors less after participating in an informal warm-up prior to testing than they typed with no preceding warm-up. Eight of the 13 typists typed from one to 18 errors more after participating in an informal warm-up preceding the testing than they typed without any warm-up.

TABLE 6

Critical Ratios Between Mean Performance Scores of 13 Typists Tested for Accuracy Without Warm-up and With Warm-up

Performance	Number of Errors				
	Mean Total for Three Trials	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	20.15	6.99	1.94	.44	1.35*
Formal warm-up	22.92	7.00	1.94		
No warm-up	21.23	8.64	2.39	.58	.75**
Informal warm-up	22.85	8.48	2.35		

*Not significant at the 5 per cent level of confidence.
**Not significant at the 5 per cent level of confidence.

PART V: STRENGTH

A critical ratio of .06 was obtained between the strength scores of twenty subjects without preliminary warm-up and with informal preliminary warm-up. This critical ratio indicated that warm-up produced no significant difference in strength scores as measured by the leg dynamometer.

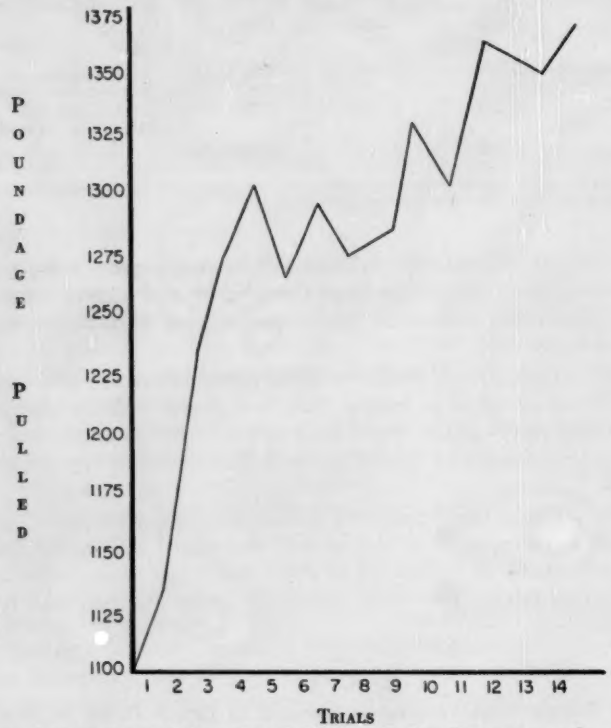

FIGURE I. Mean Total of Poundage Pulled on the Leg Dynamometer by a Group of 20 Subjects.

Ten of the 20 subjects pulled from 30 to 310 pounds more in six attempts after participating in an informal warm-up prior to testing than they pulled with no preceding warm-up. Nine of the 20 subjects pulled from 30 to 750 pounds less in six attempts after participating in an informal warm-up preceding the testing than they pulled without any warm-up. One of the subjects pulled the same poundage with an informal warm-up as he did with no preceding warm-up.

Increments in strength. An interesting observation was noted in the increments of poundage pulled by the leg extensor muscles of the group as an

TABLE 7

Critical Ratio Between Mean Strength Scores of 20 Subjects Without Preliminary Warm-up and With Preliminary Informal Warm-up

Performance	Number of Pounds Pulled				
	Mean Total	Standard Deviation	Standard Error of Mean	Coefficient of Correlation	Critical Ratio
No warm-up	4070.00	807.65	180.68	.96	.06*
Informal warm-up	4067.00	817.52	182.89		

*Not significant at the 5 per cent level of confidence.

aggregate from the first test on the leg dynamometer to the final test on the leg dynamometer. Since the subjects participated only in softball, the increments which occurred in strength were attributed to the pulling on the leg dynamometer. The mean total of poundage pulled on the leg dynamometer for the group on the first test was 1132.11 pounds. The mean total of poundage pulled on the leg dynamometer for the same group on the last test was 1370.00 pounds.

Summary and Conclusions

This study was conducted in order to determine whether warm-up affected: (a) speed in swimming a 30-yard sprint and endurance in swimming for a 5-minute period; (b) accuracy in basketball foul shooting; (c) accuracy in bowling; (d) speed and accuracy in typing as measured by amount and errors of 5-minutes maximum speed typing; and (e) strength of the legs, as tested by a leg dynamometer.

On the basis of this particular study, the following conclusions appear warranted:

1. Formal warm-up does improve speed in swimming 30 yards.
2. Informal warm-up does not improve speed in swimming 30 yards.
3. Endurance swimmers do improve in the number of laps swum in five minutes by participating in a formal warm-up prior to testing.
4. Endurance swimmers do not improve in the number of laps swum in five minutes by participating in an informal warm-up prior to testing.
5. A formal warm-up before shooting foul shots improves the accuracy in foul shooting. The critical ratio was significant at more than the one per cent level of confidence. The critical ratio was 9.07.
6. Accuracy is improved in bowling when bowlers participate in a formal type of warm-up. The critical ratio was 2.94.
7. Typists do not improve in speed of typing after participating in an informal or a formal warm-up prior to testing.
8. Informal warm-up and formal warm-up do not improve the accuracy in typing.
9. Strength, as determined by the leg dynamometer, is not improved by the subjects participating in an informal warm-up preceding the testing.

10. There is wide variability in the effect of warm-up on individual performance. In other words, warm-up seems to help performance as measured by group averages but performance of certain individuals within the group may not be improved by warm-up preceding the performance.

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(Submitted 11/5/57)

Research Abstracts

Prepared by the Research Abstracts Committee of the National Council of the Research Section, PAUL A. HUNSICKER, Chairman

26. ANDERSON, GEORGE, M.D. Research in reproductive wastage. *American Journal of Public Health*, **47**: 12: 1542-1551 (Dec. 1957).

This article concerns itself with reproductive wastage, fetal loss, perinatal mortality, pregnancy wastage, or reproductive failure. This year there will be approximately four million births; 62,000 will be social-medical problems. There will be about 883,200 reproductive failures. Four phases of this program will be reviewed. *First*, applied or developmental research in reproductive wastage. This should aid in terminology, classification, and prophylaxis. The role of heredity, prenatal and postnatal infection, oxygen lack, and difficulties in early respiration at birth can be clarified. *Second*, fundamental research or basic science correlations. Mathematics is important for statistical predictions and chemistry because of the constant relationship between mother and embryo. Other sciences continue to contribute along with the interaction of glands. The effects of viruses and fetal life are most important. *Third*, we need continued parallel animal experimental studies. Special laboratories with biologic orientation toward reproduction must be developed in a university environment.—*Joseph E. Lantagne.*

27. ANDERSON, JOSEPH T., ADRIAN LAWLER, and ANCEL KEYS. Weight gain from simple overeating. II. Serum lipids and blood volume. *Journal of Clinical Investigation*, **36**: 81 (Jan. 1957).

Twenty schizophrenic men increased their calorie intake without changing their physical activity, and carbohydrates plus 1/3 of the extra calories of mixed fat were added to the diet. The total fat intake increased, but the calories from fat decreased. The average calorie increase for 20 weeks ranged from 8-39% with weight gains from 2.5 to 22.2 kg. The average total serum cholesterol concentration increased 20 mg. per 100 ml. in the first 5 weeks, then leveled off during 15 more weeks of overeating. The weight gain continued an average of .5 kg. per week. The concentration of the S_f 12-20 lipoprotein fraction in the serum increased from the tenth to the twentieth week.

Weight gains were associated with increased circulating plasma and blood volume during the first weeks only. The indication was that the increase in serum cholesterol reflects the total fat ingestion because it is a necessary part of the lipoprotein fat-transport system. In positive calorie balance, the absolute fat intake may be a better measure of the fat metabolism load.

The suggestion is made that the serum cholesterol concentration is determined by the fat transport load per unit of circulation. In positive calorie balance, the fat transport load is increased even if the character of the diet is constant. Some serum cholesterol rise would then be expected even on reduced fat diet during the active phase of gaining weight.—*Ernest Michael.*

28. CEBOLLERA, AGELES, and MARIA E. DIAZ. Action research as a method in public health education. *American Journal of Public Health*, **47**: 10: 1265-1268 (Oct. 1957).

The aim of this paper is to describe a teaching experience in the utilization of action research as a method of training public health educators in the school of medicine at the University of Puerto Rico. In 1951 a family planning and fertility research program was started. The first step had emphasis on planning together with information on birth control; second step was concerned with wife and husband communication; third was a combination of improved communication and birth control. This study involved

a considerable period of training and planning as knowledge per se does not necessarily change behavior. To evaluate the training, the staff used such instruments as the ideology test, an attitude test, sociometric test, and content test. The project was enjoyed by the staff and participants. The use of action research should be encouraged.—*Joseph E. Lantagne.*

29. Chandler, Robert E. The statistical concepts of confidence and significance. *Psychological Bulletin*, **54**: 429-430 (Sept. 1957).

The statistical concepts of confidence and significance have been confused in recent psychological literature. Lack of explicit terminology may lead to the false belief that there is no difference in the two concepts. Strict terminology is needed if this confusion is to be avoided when giving information about the probabilities of committing errors in interval estimation and in testing hypotheses. The concept of confidence is used in interval estimation. The confidence coefficient is a probability statement that an interval, established by a sampling process, actually contains a parameter. Hence, if one has a 95% confidence interval, one knows that 5% of the time the interval will not contain the parameter. This is all there is to know about being wrong in interval estimation.

The concept of significance is used in testing hypotheses. Two types of error can be committed in accepting or rejecting the hypothesis. A Type I error is made when a true hypothesis is rejected. A Type II error is made when a false hypothesis is accepted. When a hypothesis is tested, the probability that a Type I error will be made is defined as the significance level. Hence, information is given only about a particular type error. An examination of the other type error helps further with the contrast. If β represents the probability that a Type II error will be made, then $1-\beta$ is the probability that a false hypothesis will be rejected. By definition, $1-\beta$ is the power of the test and is the basic concept which makes it possible to employ statistical tests to take some action on the hypothesis.—*Frances Z. Cumbee.*

30. Cron, G. W., and W. H. Pronko. Development of the sense of balance in school children. *J. Educ. Research*, **51**: 1 (Sept. 1957).

The subjects were 501 children who played on 14 summer play-grounds in Wichita, Kansas. The ages of the 332 boys and the 179 girls ranged from 4-14 years. The subjects attempted to make a round trip on a balance board made of a "2 x 4" 12 ft. long and elevated two inches from the ground. The board swayed and sagged somewhat as it was supported only at the ends. Each subject was given three trials and scored two points for making a round-trip and one point for walking one length.

The scores of all age groups from the 4-6 to the 11-12 group are progressively higher. The scores of the 12-15 year group are slightly lower than those of the 11-12 group. Because some subjects were watched and others not, the writer suggests that the study be repeated under the condition of competition vs. non-competes.—*Edna Willis.*

31. Doehring, D. G. Conditioning of muscle action potential responses resulting from passive hand movement. *J. Exp. Psych.*, **54**: 4 (Oct. 1957).

The action potentials of the extensor digitornum muscles of one group and of the flexor digitornum muscles of another group were recorded during passive movements (extension in one case, flexion in the other). Significantly larger muscle potentials occurred for both experimental groups during passive movement than for their respective control groups. It was also discovered that conditioned muscle action potential responses occur when passive movement is used as the UCS.—*Edna Willis.*

32. Friedman, Meyer, and Ray H. Rosenman. Comparison of fat intake of American men and women. *Circulation*. **16**: 339 (Sept. 1957).

It has been recently reported that there are groups relatively immune against overt coronary artery disease. In particular, reports show that American women before the age of 40 are 20 times more resistive to symptomatic coronary disease than the male

counterpart. For these reasons this study was conducted showing that the fat intake of husbands and wives is not different and therefore the immunity against coronary disease may not be dietary in nature as suggested by others.

It is pointed out that the American Negro woman lacks the American white woman's protection. The protection dwindles when the white American woman becomes hypertensive or diabetic. The suggestion is made that socioeconomic stress is probably a most important factor in the incidence of coronary disease. Objective attention to this factor should be given much more attention.—*Ernest Michael.*

33. Grant, D., and N. Caplan. Studies in the reliability of the short-answer essay examination. *J. Educ. Research,* **51:** 2 (Oct. 1957).

The findings of the studies support the view that reliable essay examinations can be constructed and show that the "comprehension" items are less reliably scored than are the "factual" ones.—*Edna Willis.*

34. Hammond, W. H. The Status of physical types. *Human Biology,* **29:** 3 (Sept. 1957).

An historical approach to the study of body types is made with some theoretical considerations for any classification system. The author states that the chief weakness of somatotypes is that the types themselves are arbitrary and complexly related while the different measuring scales have not been studied sufficiently in relation to each other and to the types, and the form of the measurements make it impossible to construct theoretical distributions for these variables. Factor types offer no generally agreed solution equivalent to the somatotypes with the advantages of comparability for different investigators, but they have a more objective and theoretically advanced basis although they are too dependent to some extent on the measurements selected and the factor method used. The major physical types agree closely at different ages, but the complication of assessing factor types by regression equations presents a serious difficulty in popularizing factorial methods. The author proposes a compromise type based on three components—length, muscle, and fat—measured in standard deviation units and expressed by positive and negative numbers whose magnitude indicates general size and whose pattern shows the type distinction. The scheme would be supplemented by photographs.—*D. B. Van Dalen.*

35. Hancock, Ernest W., and Walter H. Abelmann. A clinical study of the brachial arterial pulse form. *Circulation,* **16:** 572 (Oct. 1957).

Direct brachial arterial pressure tracings from 250 patients were analyzed. In 40 "normal" subjects the systolic upstroke duration ranged from .06 to .20 seconds, and with aortic stenosis cases, the time was prolonged to between .14 and .24 seconds. The aortic insufficiency patients had bifid systolic peaks and flat dicrotic waves but these same characteristics are found in other high-output states.

Other than a shortened systole upstroke there was little that could be used as a clinical diagnostic test. The arterial tracings encountered in normal subjects varied considerably and overlapped to some extent with disorders of the circulations. There was evidence however, that the brachial pressure pulse may serve to confirm a diagnosis of aortic stenosis while not yielding information as to the severity of the lesion. The procedure did show usefulness in measuring the diastolic pressure when sounds were heard down to zero using the sphygmomanometer.—*Ernest Michael.*

36. Hansen, Arild E., M.D. Role of dietary fat in human nutrition. *American Journal of Public Health,* **47:** 11: 1367-1380 (Nov. 1957).

The role of fat in human nutrition has received a great deal of attention in the last few years. It has been the subject of much controversy. Early studies revealed that infants with chronic eczema tended to have iodine numbers of the serum fatty acid which were in lower range than those of control infants having no abnormality of the skin. Fatty acids proved not to be a panacea for eczema. The next step was to measure fatty acids in the blood and body tissues. Next came the study of diets with low fat

content. It is no accident that natural food of babies contains some three to four times more linoleic acid than is present in cows' milk. Arteriosclerosis is not a problem in childhood but one may conjecture that adequate intake of linoleic acid may have influences in later years.—*Joseph E. Lantagne.*

37. JENKINS, NOEL. Effects of varied distance on short-range size judgments. *J. Exp. Psych.*, **54**: 5 (Nov. 1957).

Forty-eight students, 24 of each sex, who were attending the University of New Brunswick were the subjects of this study. None of the subjects was familiar with size-distance theory. A standard card four inches square was placed at a distance of 20 ft. from the eyes of the subjects. Cards of various sizes were then placed between the subjects and the standard card. Some subjects first made judgments about the sizes of various cards when they were placed equal distances from the subjects and then made judgments about cards at disparate distances. Other subjects did the reverse. Analysis of variance showed that prior experience with cards at equidistances had no significant effect upon subsequent judgments. A highly significant difference was found between judgments made at ten feet and those at two feet. There was confirmation of the prediction that nearer objects would yield a larger match, and that accuracy would deteriorate from the far to the nearer position of comparison.—*Edna Willis.*

38. KARLIN, ROBERT. Physical growth and success in undertaking beginning reading. *J. Educ. Research*, **51**: 3 (Nov. 1957).

Using as subjects 110 pupils in the first grade of four public schools, the writer determined the degree of relationship between certain measures of physical growth used singly or in combination, and test scores made on reading readiness and reading achievement tests. The aspects of physical growth, height, weight, and carpal measurements do not appear to be related to reading-readiness. Although the relationship between skeletal development, determined by carpal measurements and achievement, is definite, "it is too small to overcome the influence of chance when predictions of the dependent variables are attempted."—*Edna Willis.*

39. MCNEMAR, QUINN. On Wilson's distribution-free test of analysis of variance hypotheses. *Psychological Bulletin*, **54**: 361-362 (July 1957).

Because of intuitive appeal and easy computations, Wilson's distribution-free test of analysis of variance hypotheses (applicable to the fixed effects model) may be uncritically used rather than the F test. A comparison of the F test and the Wilson test on seven groups of data for columns, rows, and interaction is given. The .01 level of significance by the F test was reached in 11 instances. In six of the 11 instances, the Wilson test failed to reach this level. The .05 level reveals something of the same picture. The results of the comparison suggests that the power of the Wilson test is low and that individuals interested in detecting effects would not want to risk its use. Norton has suggestive adjustments for data not meeting the assumptions of the F test. The suggestions may be found in Lindquist, *Design and Analysis of Experiments in Psychology and Education.*—*Frances Z. Cumbee.*

40. MEAD, A. R., and BERNICE SMITH. Does the true-false scoring formula work? Some data on an old subject. *J. Educ. Research*, **51**: 1 (Sept. 1957).

A two-alternate test of 145 items was given to students who, after marking a statement true or false, indicated the degree of their sureness by circling a capital S if very sure, a capital D if doubtful, and a capital G if the answer was a complete guess. The division of right and wrong "sure" judgments was not a 50-50 one; the doubtful judgments approached equality but showed large variation; the pure guesses were not divided 50-50.—*Edna Willis.*

41. OLSEN, ROBERT, M.D. Dietary fat in human nutrition, *American Journal of Public Health*, **49**: 12: 1736-41 (Dec. 1957).

This is a summary of original researches reported by Drs. Ancel Keyes, Francisco Grande, and Theodore Van Itallie. The data presented at this symposium goes far beyond the classical teaching that fat provides calories, a vehicle for fat soluble vitamins in human diet. There is a definite need for C18 dienoic and trienoic fatty acids in infant nutrition. These fatty acids seem to maintain the integrity of the skin and increase over-all food utilization. The adult has to be concerned with too little, too much, or the right kind of fats. Since the leading killer in the U.S. is coronary artery disease, the regulation of kind and amount may be most important and significant. Keyes and Grande support the association between coronary artery disease, the elevation of serum cholesterol, and high intake of fat. Beveridge indicates that the amount of unsaturated fat in the diet is important. Coronary artery disease is more prevalent among the obese. The loss of weight lowers the serum cholesterol temporarily; however, these findings need further development.—*Joseph E. Lantagne.*

42. Rosen, Sidney, The decline and fall of high school physiology. *School and Society*, **85**: 308 (Oct. 26, 1957).

An abstract from a doctoral dissertation on the history of science teaching. The author reviews the growth of physiology and presents data showing that in 1900—27.4, 1910—15.3, 1915—9.5, 1922—5.1, 1928—2.7, 1934—1.8, and 1949—1.0% of pupils enrolled in physiology in the last four years of public high school.—*D. B. Van Dalen.*

43. Russell, Ivan L. Behavior problems of children from broken and intact homes. *Journal of Educational Sociology*, **31**: 124-29 (Nov. 1957).

Two groups of 174 children were matched for age, sex, race, and intelligence. However, one group came from broken homes and the other came from intact homes. The purpose of the study was to see whether certain behavior characteristics were associated with children from broken homes and to explore the relationship between the kind of behavior observed and the kind of home in which the child lived after the break occurred. There were several tentative conclusions: (a) Children from broken homes have significantly more behavior problems than those from intact homes. Lying and stealing in particular are more common. (b) Enuresis, extreme anger, and disobedience are found more frequently in homes broken by divorce or separation than in homes broken by death. (c) Academic retardation is more common in children from homes broken by death.—*Bruce L. Bennett.*

44. Striffler, David F., D.D.S. Criteria to consider when supplementing fluoride-bearing water, *American Journal of Public Health*, **48**: 1: 28-37 (Jan. 1958).

The purpose of this study is to explore criteria for the supplementation of a fluoride-bearing community water supply. The classical 21-city study by Dean established 1.0 PPMF as about the optimum for the U.S. in general to reduce dental caries and not cause objectionable dental fluorosis.

The conclusion and summary deals with the tangible costs in capital outlay and operational costs; the tangible benefits; the majorities and time-consuming fluoride battles; anticipated reduction of caries and additional problem of weather, climate, water works, technical complexities, and economic status of the community.—*Joseph E. Lantagne.*

45. Walters, C. Etta, and Miriam J. Partridge. Electromyographic study of the differential action of the abdominal muscles. *American Journal of Physical Medicine*, **36**: 259-268 (Oct. 1957).

A detailed and comprehensive electromyographic study of abdominal muscle function was done on two subjects with good abdominals. Recordings were made on an eight-channel ink-writing Offner crystograph. The upper and lower rectus abdominis, internal obliques, external obliques, and rectus femoris were studied. The external obliques were fractionated and the activity of the anterior, middle, and posterior fibers analyzed. The

rectus femoris was used to indicate roughly the comparative participation of hip flexor and abdominal activity.

Results showed the trunk curl to be one of the most effective exercises for all abdominal muscles, and the "V" sit-up to be an extremely powerful one. The upper rectus abdominis participated more in activities involving the upper trunk, and the lower rectus in activities involving the pelvis, although participation of one was always accompanied by activity in the other. In activities in which both muscles were used as stabilizers, such as double leg lifting, the muscle that was farthest from the weight that was being lifted was the one that fired the most. Trunk rotation was performed largely by the internal obliques and not by the externals as is commonly thought.—*C. Etta Walters.*

46. White, Colin, Marvin Reznikoff, and John W. Ewell. Usefulness of the Cornell medical index health questionnaire in a college health department. *Mental Hygiene*, **42**: 94-105 (Jan. 1958).

The Cornell Medical Index Health Questionnaire was administered to 784 college freshmen as part of the routine physical examination. Records were kept for two years to determine which of these students visited the mental hygiene clinic. A positive correlation was found between the number of questions answered "yes" and the percentage of students visiting the clinic. For example, 42% of the students who had 30 or more positive replies reported to the clinic as compared with 4% of those with less than five positive replies. Some effort to measure the reliability of the Index was made through checking five questions by a follow-up interview, but it was not too satisfactory. The authors express their belief that many of the questions are not relevant for a college population which is healthier than the general population.—*Bruce L. Bennett.*

47. Whipple, John. A study of the extent to which positive or negative phrasing affects answers in a true-false test. *J. Educ. Research*, **51**: 1 (Sept. 1957).

A total of 940 statements were presented to 271 students. No significant difference was found between the questions phrased negatively and those phrased positively. A significant difference was found between keyed answers, either "true" or "false," and between the items of a non-scientific nature and those of a scientific nature. A very significant difference occurred between the phrasing of the statement and the keyed answer.—*Edna Willis.*

48. Wilson, Kellogg V. A distribution-free test of analysis of variance hypotheses. *Psychological Bulletin*, **53**: 96-101 (1956).

A nonparametric test of the hypotheses about main effects and interaction in the analysis of variance model has been presented. (It may be noted that Siegel in his *Nonparametric Statistics for the Behavioral Sciences*, p. 33, called attention to the fact that distribution-free methods for testing interactions were not available. After the book was in type, a footnote was added calling attention to the article being abstracted here.) The method developed is a modification of Rao's technique (*Advances Statistical Methods in Biometric Research*, pp. 192-205) for determining additive parts of a chi-square statistic for a contingency table. Scores are classified in each cell as falling above or below an over-all median. The total chi-square, as a sum of squares in the analysis of variance, is then apportioned into components. An example illustrates how chi-square values are obtained and how the tests for main effects and interactions are made.—*Frances Z. Cumbee.*

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